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OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE





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Virginia Institute of Marine Science Gloucester Point, Virginia 23062 Received January 18, 1971

Fish for Beauty in Dismal Swamp!* (One Man's View of the Swamp)

Origin and Climate

The life-blood of lakes is carried in feeder streams. Whether rushing or percolating, water takes nutrients from soils to lakes. Where the soil is rich, lakes are productive; where the soil has been laboriously weathered from stubborn metamorphic rocks or sand deposits, lakes are infertile. But what are the lifegiving resources of a lake that pours its waters in exodus? For such is Lake Drummond, the heart of the Great Dismal Swamp. The Swamp lies 15 to 27 feet above sea level on a terrace sloping gently eastward. To understand the energetics and ecology of this dying swamp, one must consider the origin of the basin and the climate of the area.

That lakes begin to fill as soon as they are created and that they have usually short geologic lives is axiomatic to limnologists. A map (1) reveals that Lake Drummond now comprises only a small fraction of the original Dismal Swamp basin. In short, Lake Drummond is the remnant of a much larger lake that once filled the basin of the Swamp. A shallow basin with restricted outflow soon becomes stagnant. Acid conditions arise that result in slow and incomplete decomposition of organic matter, hence, peat accumulates. The basin of Dismal Swamp is mostly filled with thick beds of sponge-like peat from which waters escaped slowly in colonial days.

Barrier islands and beaches with lagoons behind them at the junction of ocean and land are familiar features of maps of the North Atlantic coast from New Jersey to Texas. At Cape Henry, large moving sand dunes were active until recent years. In 1799, Latrobe (2) reported that dunes near the Old Cape Henry Lighthouse in Ft. Story had moved 350 feet in 15 years. The Great Dune in Ft. Story, referred to by Egler (3) in 1942 is gone—a victim of military development and civilization. In 1963, I visited another active dune moving southwest into the swamps or "desert" of Seashore State Park. One block landward of the Virginia Beach Boulevard, one emerged abruptly at the base of a nearly bare dune rising in one-quarter mile some 90 feet, then dropping precipitiously to a freshwater lagoon. Large

trees were being buried by sand on the steep lee slope. Now this last great dune near Cape Henry is "dead" and houses and weeds dot its bulldozed crown. The steep leeward slope remains, stabilized by weeds and vines.

The origin of the Dismal Swamp basin is illustrated, I believe, in these wind-blown dunes and in miniature profiles at Cape Henry today. In Scashore State Park are forested alternating crescentric ridges and lagoons representing former barrier beaches and their lagoons. These are now covered with a climax association of cypress and gum trees in the wet swales, and scrub oaks with members of the heath family predominating in the understory of the dry burned-over sand ridges. The Seashore State Park runs quickly from foredunes on the shore of Chesapeake Bay to these striking freshwater swamps and ridges. The appearance of the plants in these alwayswet swales gives one the illusion of being a thousand miles south of Virginia. The live oaks, a profusion of spanish moss, and evergreen broad-leafed plants with southern affinities seem to deny Virginia's climate. Dismal Swamp nearby is also a northern outpost for many southern species of plants and animals.

This spectacular change from salt-spray adapted communities to semi-tropical freshwater swamps is made possible by temperature moderation from proximity to the ocean and aggradation of continental shelf sands during a period of relative stability of sea level. Could not the basin of Dismal Swamp have been created by similar large, moving sand dunes when the ocean was slowly rising on the Dismal Swamp Terrace (+15 to +27 feet now) in the past 6,000 to 9,000 years? The origin is being studied by geologists from borings, underlying sediments, and stratigraphy of the surrounding region. Irregular depths of peat might suggest a basin invaded by moving dunes, although allowance must be made for burned-out peat layers, for almost none of the Swamp seems to have escaped fires. Reports of fine white sand suggest wind rather than wave origin of the sediments beneath the peat.

The southern affinities of plants and animals suggest that climate has not changed greatly in the coastal area in the last 10,000 years. Coastal zones may have been sanctuaries even in the ice ages for Dismal Swamp is close to the ocean with its protec-

^{*} Editor's Note: This is the fifth of a series of articles on the Dismal Swamp appearing in The Virginia Journal of Science (see references 1, 6, 13).
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tive humidities and temperatures. Climate is strongly moderated by proximity to the oceans, and the Gulf Stream which carries 1,000 times as much water as the mighty Amazon River helps provide a local maritime climate.

Images, Dreams and Drainage

The clearest images of the primeval Dismal Swamp come from the pens of William Byrd (4) and Edmund Ruffin (5) who, over a century apart, described the Swamp before man had removed much of its water. We are fortunate that Byrd, a gentleman of highest rank in his time, was a literary man —if a bit fastidious about habitats suitable for man or beast and a rather poor naturalist outside his library. Ruffin was far ahead of his contemporaries scientifically. He gave a penetrating account of the Swamp and recognized the value of humus in soil and its ephemeral tendency with drainage. If one skips the "poetic" embellishments, Byrd, without entering the Swamp, paints a picture of a flooded tangled mass of vegetation, fallen junipers, with rare dry spots where men could bed down without lying in water. Water stood knee-deep for miles along the

The boundary survey was conducted in wet, cold, March—apparently to avoid snakes and insect pests —because the remainder of the boundary was run in the fall when temperatures had dropped again. Curiously, a foray for snakes in the summer of 1950, with a party of four and two experienced herpetologists, yielded many snakes but only one water moccasin and that caught by the author, an amateur. Perhaps a fear of snakes loomed large in Colonel Byrd's mind in organizing the survey. Byrd surveyed in late winter which is about the wettest season in

Virginia but it was a "dry" year!

The key to the past and future of Dismal Swamp is water! Since fish require water around the year, it is essential that each reader paint a picture in his mind of the undisturbed swamp as a fish habitat. Probably Lake Drummond played a minor role as habitat for the original fish populations of the Swamp -a conclusion drawn from the size and present hab-

itats of these fishes.

In the past, Lake Drummond and its surrounding sphagnum-forest community clung tenaciously to the water from a 50-inch annual rainfall and remained wet without benefit of inflowing streams. One can imagine that in the wet season water flooded most of the swamp with its forest of moisture-loving cypress, juniper, and black gum trees and a host of wet-land associates. Many large shallow lakes were created in the forest by the damming effect of vegetation and these were colonized to advantage by aquatic insects and small fishes. Near the end of the wet spring season, multiple canopies of leaves formed by deciduous trees and shrubs protected and conserved water from evaporation by sun and wind and moderated temperatures. During the warm season, stagnant conditions resulted in acid waters and slow decomposition of leaf litter and buried wood. Sphagnum moss covered the forest floor and blocked rivulets by which water sought to escape. Thus swamp

and lake in a few thousand years had arrayed Nature's forces in a subtle but effective water balance which assured the well-being of all inhabitants.

Poor drainage is as natural in swamps and marshes as sand in deserts but to have a living swamp close to the ocean on a plain or terrace some 20 feet above sea level is astonishing and tempting to man. Proposals for draining the Swamp began early but actual plans were made by a young surveyor named George Washington, who first realized the lake was elevated above the surrounding Coastal Plain. History often turns on the foibles and mistakes of powerful men. The dream of rich farm lands that Washington and his friends saw in a drained Swamp slowly proved to be a mirage not yet fully dispelled in the minds of men. The story of old and new ditches, dug to navigate, drain and unwittingly bleed the Swamp, and the reasons why, are told elsewhere in this series of articles. One need only compare the older map by Henry (6) with the recent one by Ramsey, et al. (1) to see how effectively man has thwarted Nature's plan to conserve the water supply of the Swamp. After virgin timbers were ravished, "benign neglect" by man permitted the Swamp to begin repairing damage by gradually chocking the ditches with vegetation. It was in this state that I first saw the Swamp with an ichthyology class from William and Mary College in the late 1940's. The closed end of Jericho Ditch, for example, was clogged with aquatic plants, leaves and branches—and teeming with glorious-colored fishes.

The Swamp That Was

Removal of water has already tamed the Swamp. No longer are its mysteries shrouded by an impenetrable morass. Fishing and hunting parties go in by boat, but the forest floor is only damp and seldom flooded. During much of the year one can walk over it in street shoes. The deep layers of peat have dried and burned many times. Shallow Lake Drummond, once pushing into a forest studded with cypress and gum trees, now has a bare treacherous rim and a snag-filled border in summer (Fig. 1 and 2). When I first visited the Swamp (1948), the old ditches that man dug to drain it were cut off from the lake and had formed a series of brush-filled pools. What chance has the lake to draw nutrients from the forest or the forest to gain its protective cloak of water from the lake? They no longer embrace each other inseparably. Nature discommoded usually lacks beauty and harmony. To those who have imagination to perceive its primeval glory, Dismal Swamp is sadly ravaged.

Two centuries ago the colonists of Eastern Virginia were actively interested in Dismal Swamp; it offered pure drinking water, rich timber and a reservoir of water for canal transportation. After most of the timber had been cut or burned out, the Swamp had many decades of relative freedom from the obtrusions of men. Recently a renewed interest has been shown in cultivating the land and growing timber. An extensive series of ditches and water gates has been established to control water level. Today those who most frequently dip oars in the coffeecolored waters of Lake Drummond are pleasure-

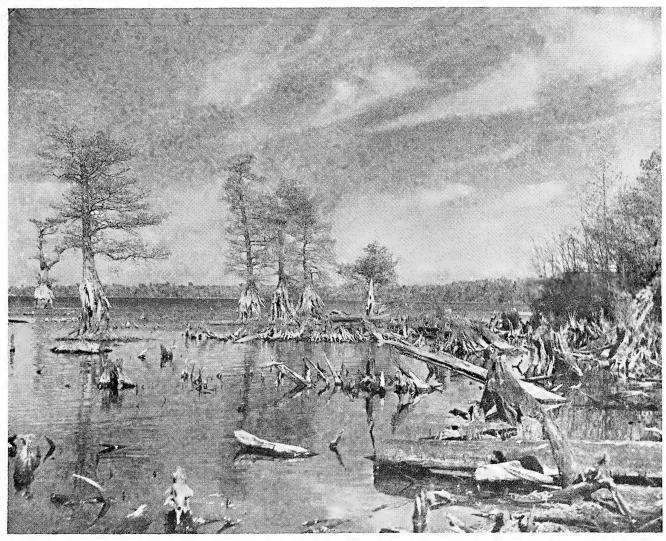


Fig. 1—Shoreline of Lake Drummond at relatively low water. (Virginia State Chamber of Commerce photo)

seeking fishermen, hunters, camping boys, and forestry personnel. Few people have an interest in or knowledge of the Swamp. The water is no longer sought for its supposed curative powers; the native forests are badly depleted and only a few fishes of the original populations are still there. They are little fishes of a variety and beauty to satisfy boy scouts and naturalists but provide poor material for fishermen's creels or fireside tales. The beauty that swims in the waters of Lake Drummond could yet help draw many generations of imaginative boys for a faint glimpse of the wild morass which Thomas Moore made famous with his mystic poem about a lost Indian and his maid. Although forestry is still the most promising commercial venture in the Swamp, it may have been improvident to clean and dig bigger ditches which will further drain the "heart" of the Dismal Swamp. Habitats for the "little fishes" have rapidly disappeared.

Unique Biota Poorly Known

It is ironical that Virginia with its rich plantations

which provided so many pre-Civil War leaders should be so impoverished in knowledge of fauna and flora. This ignorance is especially surprising in view of the fascinating variety of organisms to be found. Virginia is a transitional zone for many groups of organisms. Here southern and northern species are intermingled. Field guides often do not cover Virginia's biota adequately. Resident taxonomists are lacking for many groups. Most early information about biota has been gleaned in hurried forays by northern professors on vacation. John Clayton, an early resident of Gloucester County, collected plants to be named by Europeans. He was honored by having named for him the pretty little common wetland flower called spring beauty, Claytonia virginica. The usual pattern of learning about a specific group is well exhibited by Fernald, a botanist from Harvard. Fernald, two centuries after Clayton, made several spring and summer collecting trips to Tidewater Virginia and left some fascinating accounts of his delightful experiences locating rare and transitional plants—particularly around Dismal Swamp. Some

groups such as birds and reptiles are better known than most because hobbyists form clubs and compete for the longest lists of species. Also reptiles are considered good pets by many boys and men although we still have "Colonel Byrds" among us. Fish hobbyists seem to be of a different breed that depend upon pet stores and home aquaria—or they are fishermen seeking large size and fight in a fish.

Fish Refugees

Eastern North America, with its large and varied river systems and many lakes, has one of the richest fresh-water fish faunas on earth. North-south running mountains and river systems permitted faunal groups to move with glaciers and survive. All major groups are represented from archaic to advanced spiny-rayed fishes. Six fresh-water fish families are peculiar to North America and three others are nearly so, except for relic species in Asia. All but two of these nine families are represented in Dismal Swamp although the primitive gar pikes and bowfins are large fishes confined to Lake Drummond. The European ichthyologist would find most of the fishes

of Dismal Swamp quite strange. Europe has only one-fifth as many species as North America and most of these are in the aggressive minnow family and its relatives—a group conspicuously lacking in the swamp despite man's importations as rough or bait fish.

The distribution of fresh-water fishes occupies a dominant role in studies of the history of continents on earth. Without man's help these fishes could move from one continent to another only by way of fresh-water connections. The approximate time and order that once-continuous continental land masses were separated can be deduced by studying the "family tree" of fishes. How fortunate we are as naturalists or fishermen to be able to enjoy the richness of our fish fauna, and how unfortunate that our government with professional advice introduced alien species such as the carp—unneeded "weeds" in our streams. And, as usual, these introductions were made before we fully knew the kinds and distributions of our native fishes and their ecology much less the effect of immigrants on them. Fortunately, Dismal Swamp like most natural communities has



Fig. 2—Lake Drummond with Cypress butts near shoreline. (Virginia State Chamber of Commerce photo)

shown remarkable resistance to such importations. "Poor" habitats are often refuges for weakly-competitive species. The "little sunfishes" seem especially adapted to niches of shallow waters with densely interlaced vegetation.

Collecting for Beauty

The earliest ichthyologist to work in Virginia was the famous David Starr Jordan—later the first president of Stanford University. In 1888 he collected around the edges of the Swamp and obtained a rather complete list of the species present except for the big fishes in Lake Drummond (7). Just about 60 years later I led a class of William and Mary students into the Swamp. There is no record of visits by people capable of naming the fishes before Jordan or for 60 years afterward. Although familiar with the important and rather dominant centrarchid (sunfish) family in the Mid-West, I was not prepared for the splashes of color in our nets provided by the little sunfishes of Jericho Ditch. After clearing tree limbs out of the choked dead-end ditch, we pulled fivefoot minnow seines and used dip nets to catch a nice variety of species not far from where Jordan worked in 1888. Live and preserved specimens were taken back to Williamsburg. All the fishes were new to me, but late that night after studying them with the help of Smith's "Fishes of North Carolina," I felt prepared to meet my students with some confidence.

Since that first exciting class trip some forty collections of fishes have been made in Dismal Swamp.

(This account first written in the early 1960's refers to Virginia Institute of Marine Science collections only for no others were available then.) Most of this collecting has been done by one of those original students, William H. Massmann, who judiciously used rotenone to collect all fishes of Dismal Swamp (Table I). A later class trip is vividly inscribed in my memory. In our eagerness to recover all specimens killed after adding rotenone, Bill Massmann and I got into the waist-deep ditchwater and stirred it vigorously while collecting floating fishes. Only a farm boy from the treeless plains of Kansas, as I was, could have been so foolish. Have you ever had a case of poison ivy from head to foot? It still makes me itchy to recall the scene of my wife daubing me with worthless "ivy-cure."

Any boy who has dropped a line in small streams or ponds of Eastern North America would recognize the most common spiny-rayed species in Dismal Swamp as sunfishes. These are short deep-bodied fishes of the family Centrarchidae found only in North America. But they are not the Pumpkinseeds or Bluegills which every country boy knows. The small dusky fish with rows of black spots on a very short deep body is called a Flier by fishermen. The young fish has a black-ringed orange spot near the

base of the fin on the back. The Flier seldom exceeds six or seven inches in length but even at this size is a giant to his small relatives, the "Little or Dwarf Sunfishes" which rival tropical fishes in brilliance of coloring but are seldom more than three inches

TABLE I

Collections of fishes of Dismal Swamp. Collecting was done by dip nets, gill nets, minnow seines, trawl, and rotenone. Table based on a compilation by William H. Massmann who made most of 35 collections of which 25 were counted. The gill net collections by the Virginia Commission of Game and Inland Fisheries reflect relative abundance of species in Lake Drummond. Most collections by Massmann were in ditches, canals and restricted coves. Species collected by Jordan are marked with a dash.

Common name	Scientific name	Lake Drummond	Va. Commission catches	Ditches	Canals	No. of Occasions Caught	No. of Individuals
Longnose Gar	Lepisosteus osseus	X	. 5				
Bowfin	Amia calva	X	6	X	X	4	14
Mudminnow	Umbra pygmaea	X		X—	X	10	69
Redfin Pickerel	Esox americanus	X		X	X	14	138
Chain Pickerel	Esox niger	X	1	X	X	2	1
Golden Shiner	Notemigonus crysoleucas	X	5	X	X—	12	824
Lake Chubsucker	Erimyzon sucetta		1		X	2	51
White Catfish	Ictalurus catus				X	2	25
Yellow Bullhead	Ictalurus natalis	X	412	X—	X	3	29
Brown Bullhead	Ictalurus nebulosus	X		X	X— X—	13	96
American Eel	Anguilla rostrata	X		X	X—	7	45
Banded Killifish	Fundulus diaphanus				X	3	7
Mosquito Fish	Gambusia affinis	X		X—	X—	7	20
Swamp Fish	Chologaster cornuta	X		X—		8	24
Pirate Perch	Aphredoderus sayanus	X		X	X	12	123
Centrarchidae	—Sunfishes						
Mud Sunfish	Acantharcus pomotis	X		X	X	5	87
Flier or Speckles	Centrarclus macropterus	X	209	X	X	20	730
Warmouth	Lepomis gulosus				X	4	15
Blue-spotted Sunfish	Enneacantlius gloriosus	X		X	X	4	23
Banded Sunfish	Enneacanthus obesus	X		X—	X	13	87
Pumpkinseed	Lepomis gibbosus				X	3	21
Black Crappie	Pomoxis nigromaculatus	X	61		X	6	90
Swamp Darter	Etlieostoma fusiforme	X		X	X	8	33
Yellow Perch	Perca flavescens	X		X	X	10	230

long. The Blue-spotted Sunfish, which scientists call Enneacanthus gloriosus, truly reflects the glory of the rainbow in its scales. The olive-green body, flecked with numerous blue spots, changes hues with every movement. The name means nine-spined glory referring to the nine spines in the large median fin on the back, and indescribable colors. The other Little Sunfish, E. obesus, sometimes called the Sphagnum Sunfish, or Banded Sunfish, has a beautiful greenish body covered with small purple or golden spots and obscure dark vertical bars. Live specimens of these tiny fishes almost defy description because of their constantly changing colors. They are hovering fishes, quick-moving but equipped to adjust their positions, forward or backward, in a maze of plants and twigs rather than for bursts of speed in open water. They make most interesting aquarium specimens. The Banded Sunfish is easily found in Dismal Swamp but rather rare in Virginia outside the Swamp. The Blue-spotted Sunfish is rare in the Swamp but more frequently found in tributaries of the James River. These little sunfishes may interbreed when living together which could account for the difficulty scientists have in separating the two kinds.

A rare member of this spiny sunfish tribe is the Mud Sunfish which lives in sceluded waters of the Swamp. Wearing conservative garb, this dark-colored fish is probably unknown to fishermen. In the small quiet pools and sloughs, which can accommodate only small fishes, the Mud Sunfish is obviously the villain of the neighborhood. Compared to lesser finmates, he has a cavernous mouth extending back beneath the eye. When caught and preserved, his gill covers thrust out like pouches on a bulldog's jaws, surely an ominous sign to his smaller relatives. His rarity comports with his habits as a real fisheater.

These Dwarf Sunfishes are confined to coastal plains waters from New Jersey south and most commonly in acid swamps. The Flier is found in the lower Mississippi River system as well as coastal fresh waters. It appears to be more competitive with the advanced sunfishes common in most lakes and ponds of Eastern North America than are the Dwarf Sunfishes.

The breeding habits of sunfishes are distinctive for the family and quite similar in most species. The name "sunfishes" is aptly chosen. The male, in brilliant garb, builds and guards a round excavated nest in shallow water fully exposed to the sun. Small territories are established which females enter to deposit eggs. In contrast to many groups of fishes, males are larger than females. Breeding occurs in late spring and early summer at temperatures higher than most fish prefer. Males discourage larger fish from entering their territory, and are necessary to protect the eggs from numerous predators. Barren sandy areas are preferred but aquatic weeds do not deter nesting although the eggs are only slightly adhesive.

The Dwarf Sunfishes do not exhibit as strong a nesting urge as the Lepomids or advanced genera. It appears that they may deposit eggs at times on

masses of vegetation or build poorer nests. Acantharcus is reputed to be very secretive about its nests leading to the suggestion that it may nest in holes or crevices. Nests are not seen when specimens are fairly common. It may be significant that male Mud Sunfishes do not dress appreciably for spring mating. The rather weak nesting habit in the Dwarf Sunfishes, which live primarily in swamps, may relate to the relative scarcity of vegetation-free sandy bottoms for nesting sites. However, in favorable sites, typical sunfish nests have been seen for all species except the Mud Sunfish.

Except for the Crappie which has been observed to tolerate acid waters in other habitats than swamps, the common sunfishes of Dismal Swamp are all primitive species. By ichthyologists' criteria, advanced genera of sunfishes have fewer spiny rays in dorsal and anal fins, and rounded rather than forked tails. Although access to Lake Drummond has been provided by feeder ditches and canals, none of the Lepomids (advanced group) have established themselves except Black Crappies. Most biologists attribute this to limitation of reproduction by acid waters but it is possible that nesting sites are not available along the vegetation-choked shores and peaty bottom of Lake Drummond. Local residents claim that Large-mouth Black Bass were present prior to the big fires of the 1930's but introductions in the 1950's failed to establish either Black Bass or Bluegills.

All sunfishes are adapted to rest quietly in still shallow waters with their large fins extended for balance. All are at home among shallow weedy coves where quick thrusts will yield insects or fish fry and where their nests are built. But the Dismal Swamp sunfishes appear to be of a size adapted to still more restricted spaces among the roots and sphagnum beds of the tree-covered swamp. Food chains appear to be short with detrital leaves, isopods and fishes being a typical one. Yet the full gamut of food habits is found in both the large advanced and the small primitive groups of sunfishes. In both groups, small insect and crustacean eaters are preyed upon by larger fish-eaters.

One of the prettiest of the dwarf centrarchids, *Mesogonistius chaetodon*, which is found in freshwater swamps from New Jersey to North Carolina, is missing from the Dismal Swamp collections. Smith describes typical small sunfish habits for this species. Recent collections in Maryland (8) suggest that the blackbanded sunfish, now placed in the genus *Enneacanthus*, inhabits swamp waters. Its absence from Dismal Swamp has not been explained.

Centrarchids are limited to North America, hence, we are sure none are of foreign origin. But I am not certain which species are native and which are introduced in Dismal Swamp. Massmann records eight centrarchid species now present of which Jordan found only four. The other four species are quite probably introduced or have invaded the area via canals and ditches. It is quite significant that three of the four are quite scarce yet and that the Black Crappie, the only abundant species, is by far the largest sunfish in the Swamp and is probably restricted to the lake itself. This species has not been

taken in the ditches. In making collections one must distinguish between lake, feeder ditches and canal habitats which exhibit increasing order of access to

waters of other drainage systems.

The most peculiar fish in the Swamp is the tiny "fish of the Dismal Swamp." This strange fish, sometimes called the Rice Fish because of its occurrence in rice paddies and ditches, belongs to the blind-fish family. Most of its relatives are blind inhabitants of caves. The Rice Fish (Swamp Fish) has eyes but also numerous sensory papillae which make poor sight a slight handicap in the dark waters of Dismal Swamp. Back in 1888, Jordan found this fish in Jericho Ditch. There is no record that this species had been found in Dismal Swamp since that time until I captured a few specimens in the same ditch in 1948. Chologaster is rare in the Swamp, although common in coastal waters farther south, and is apparently confined mostly to ditches full of brush and debris which offer plenty of protection. The name of the Rice Fish, Chologaster cornuta, means "maimed belly fish with horns," and refers to the absence of pelvic or posterior paired fins. Another peculiarity of this species is ovoviviparity or production of live young by development of eggs within the body cavity—a rare accomplishment for fishes. This statement may not be true since a related species has been shown to brood its eggs in the gill chamber.

Another peculiar fish, which we have taken in great numbers in some of the meandering rivulets leaving Dismal Swamp, is the Pirate Perch. This three- to four-inch fish, which has the shape and the rough scales of a perch, is not a perch but belongs to a group which bridges the change from soft to spiny-rayed fishes. It is a blackish-brown fish which has one other distinctive characteristic again alluded to in the scientific name, *Aphredoderus sayanus*. The vent in this fish migrates during development from the usual position to the region of the throat,

a most incongruous situation.

Jordan did not get to Lake Drummond, yet managed to find 17 of 25 fish species listed by Massmann as now present in the Swamp including the canals connecting with James River tributaries. Jordan did not find the Longnose Gar and Bowfin which are the two major predators of Lake Drummond. The Yellow Perch or Ring Perch, missing in 1888, is now very common as it is everywhere in Eastern North America but was probably introduced to Dismal Swamp.

All fishes of Dismal Swamp are dark in color compared to the same species in clearer waters. Is this an adaptive response or simply physiological accumulation of a pigment which is overly abundant in the habitat? Ever since Darwin's theory of evolution stirred our 19th century ancestors, scientists have become aware of the many ways in which animals use mimicry and color patterns to deceive their enemies. But how could it work in the dark waters of Dismal Swamp? My own guess is that these little sunfishes lived in Swamp pools of such shallow depths and so interlaced with plants and roots that dark color didn't have much meaning as a protective device. Perhaps the proof of this lies in the little blind fish which inhabits the thickest tangles of the

ditches and is almost white. The absence of pelvic fins only reinforces the emphasis on hiding in dense mats of vegetation, rather than racing or maneuvering for its life. The evolution of pelvic fins on fishes indicates that they were initially misplaced and relatively useless. Like the catfishes, *Chologaster* probably finds its food by sensory organs other than sight.

Fishing in Lake Drummond

Fishing in Lake Drummond is another story which should be told by an avid fisherman. No doubt he would emphasize the size and quantity of fish available. Most Americans have an eye for size and action but not for beauty. If it were otherwise, our people would not tolerate the enormous quantities of beer cans and papers strewn along our highways and streams. I have been describing the little communities of fishes which probably feel most at home along the borders of the Lake and in the Swamp itself. In the Lake too, centrarchids comprise most of the catch of fishermen. Black Crappies and Fliers provide good fishing in the Lake and the former reaches a suitable size for a good pan fish. Catfish are known to be very abundant in the Lake but stunted. Local residents report that Large-mouth Bass fishing was good in the Lake some thirty years ago. Disappointing by the fisherman's standards of value, Redfin Pickerel matches the size of the Little Sunfishes all too closely to grace creel baskets with its greenish body marked with dark vertical bars. Probably in response to fishermen's demands, our Commission of Game and Inland Fisheries (9) stocked Bluegills and Large-mouth Bass in Lake Drummond in the 1950's. This is one common stocking formula for ponds and lakes in the Eastern United States. Usually minnows (cyprinids) are present in lakes as forage fish for centrarchids, but Dismal Swamp is conspicuously lacking in this dominant and aggressive family of fishes. Only one species is established despite the habit of fishermen of "stocking" ponds and lakes with the left-overs of their bait pails. If Large-mouth Bass were common prior to the 1930's it is difficult to understand why intensive gill netting revealed no specimens of either species a few years after stocking. I hope that Fliers and Dwarf fishes continue to persist in the Swamp despite its "maimed" condition. There are plenty of typical lakes for Bluegills and Bass.

Past and Future; Wet or Dry?

The Clayton-Grimes Club of the College of William and Mary under the stimulus of Dr. Donald Davis and Dr. J. T. Baldwin used to conduct annual field trips to Dismal Swamp. These were memorable trips—especially when such discerning men as Dr. William Vogt, conservationist and ornithologist of international fame, went along. To the students nearly everything was strange in the Swamp. But did they really get a picture of the pristine Swamp as they walked along the "wire trail" in street shoes in May—the culmination of our wet season? They were told of the peat fires, and they saw cypress stumps in the lake but not much was said about

water moccasins nor were they seen. Certainly May is the time to go to Dismal Swamp to see it at its best—with water up to the shores, the greenery of new leaves, and the breeding colors of centrarchid fishes. We did seine for fishes. The fishes are not unique in the sense that they can't be seen elscwhere, but they do require a habitat that is rapidly disappearing as swamps are drained or converted to lakes. Very little of the shallow-water habitat remains in Dismal Swamp for these small fishes. These cypress swamps—most of which are much smaller than the Great Dismal— are fast yielding to man's manipulations. With the inexorable pressure of human populations it would be wise to start saving a few wild communities along the coastal plain—for future generations of people who may appreciate the variety and beauty of "useless" little fishes which must have some purpose and some "rights" in Nature's realm.
The future of Dismal Swamp is now in the hands

of large timber companies. Foresters say that the keys to the future are fire control and sound forestry methods. Certainly forestry is a usage far more effective than draining the swamp for farming. In the past 10 years numerous ditches have been dug and fitted with gates to drain water in winter and spring (the wet season) and hold water during the dry season. But what kind of trees are to be grown? Loblolly and pond pines, which are fast-growing but require much drier soils than the original slowgrowing cypresses and junipers, are the foresters' choices. But will Nature tolerate these manipulations of water on the Swamp's peat soils? No provision is made for relieving summer droughts which was dramatically demonstrated in 1963 with the ditch-control system in operation. The lake shrunk drastically from its normal shoreline.

Edmund Ruffin over 100 years ago (1845) recognized the importance of humus in soil, but also noted that it "burned" out in warm climates such as his beloved Confederate States enjoyed. He also wisely recognized that the vegetable soils of Dismal Swamp would not last unless saturated with water to retard rotting (bacterial and fungal decay—which he knew nothing about since bacteria were only then being discovered).

I repeat that water and water alone is the key to the preservation of Dismal Swamp as a wild area with its rich components of southern fauna and flora. Habitat for the little native fishes is almost gone and now the ditches where they are making their last stand are being dug out and kept clean. The ditch, where my class in 1948 had to clear branches before a five-foot minnow sicne could be hauled in water three to four feet deep, was a wide bare-banked ditch with a trickle of water the last time I visited it. The Swamp, which formerly stored its 50 inches of annual rainfall in winter and spring to ease summer droughts, gets annual "bloodletting" to cure its ills. Poor George Washington, who led the efforts to drain the swamp, never learned the lessons about bloodletting and died from it. Good forestry management and a stand of loblolly pines will help conserve the peat but the real cure is Nature's own remedy—more water.

There is no longer any excuse to permit the feeder ditch to rob Lake Drummond of water for the Intra-Coastal Waterway. This is the age of unlimited power. Hydroelectric plants can afford to pump water back into reservoirs for re-running through power plants at hours of peak demand. The Intra-Coastal Waterway which serves mostly pleasure craft, can be supplied with pumped water or more efficient lifting devices. The feeder gate at the Lake could then be raised and those who care enough to see the Swamp could hoof it in a short three miles! Probably the government would put in a monorail to insure that no one's privileges are abridged, but with plenty of water the Swamp could tolerate many

people.

For an impression of how "civilized" Dismal Swamp is now, one must turn to Alexander Sprunt's (10) beautiful description of "preserved" cypress swamps in the Carolina Low Country. Here water and cypresses have been retained because rice farming in earlier times led to a system of water impoundment. As Sprunt observed, only canoe and paddle are harmonious with these watery realms. In contrast the entry into Great Dismal Swamp by motor boat follows a straight dug canal with high banks of spoil which mercifully block from view the encroachments of farming on the Swamp's borders. This is just another man-made ditch which serves as a bleeding artery from the heart of the Swamp and from it one sees mostly the usual "weeds" which accompany man's every disturbance of Nature. Yet Dismal Swamp was big and something of its original beauty might be restored if its essential ecological requirement is met—save all water! Save our "dwarf fishes" for the next "culture" in America. It must be realized that people are part of Nature's realm and that Nature will make us pay for our greed, our wastefulness, and our sick habitats called cities. Most important, we must respect the fundamental law on this earth—that all populations, including man, must be limited and controlled.

Dismal Swamp cannot be restored to its pristine state. It could become a fascinating refuge for cypress swamp species. After three centuries of plunder and manipulations by men, the usage best suited to conserve the Swamp cannot be agreed upon by foresters, fishermen, and even scientists. I think preservation depends upon restoration of the ecological conditions which created the Swamp. A basin with poor drainage will once again favor the original inhabitants and create a natural area of mystery, wonder, and variety for future generations of men and little fishes.

Postscript

The present author has indulged in comments and opinions that impinge on several other fields, and would expect considerable disagreement about origins, fishing management, forestry programs and water conservation. See Oaks (11 and 12) for origins and recent stratigraphy. The forestry program (13) is not as simple as I have portrayed it for hardwoods are grown, too. Lastly, there is need for scientific treatment of the ecology of fishes of the Swamp.

Acknowledgments

I wish to thank William H. Massmann for permission to use the list of species and collection data in Table I. Photographs were supplied through the courtesy of the Virginia State Chamber of Commerce.

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Two Procedures of Presenting Concepts to Children

Abstract—Performance efficiencies of two methods of presenting concepts for learning were compared. Fourthgrade Ss learned simple concepts by dividing wooden blocks into groups according to shape or color. One method, the selection procedure consisted of presenting simultaneously the total array of stimulus patterns and Ss selected instances of the concept from this array. The order of selecting instances by Ss in the Selection Group was presented successively and individually to yoked Ss in the Reception Group. The results showed that concept learning was more efficient with the reception procedure than with the selection procedure. Results were in agreement with previous studies of Huttenlocher with seventh-grade children and Murray and Gregg with adults.

One of two different procedures of presenting instances of concepts is usually used in studies of concept learning: a reception procedure or a selection procedure. With the reception procedure instances of concepts are presented successively and individually and the S is required to indicate whether the instance is the concept. With the selection procedure all instances are presented simultaneously and the S is allowed to choose the order of selecting instances of the concept (1). Few studies have attempted to compare the efficiency of both procedures.

A recent attempt to compare the procedures was performed by Huttenlocher (2). In this study, Ss—seventh-grade children—were divided into two yoked groups. One group, called a "manipulating group," was allowed to construct a stimulus pattern on each trial by placing objects in a form board. The other group, called "nonmanipulating," was shown instances of patterns constructed by their yoked counterpart. Significantly more correct solutions were obtained by Ss in the nonmanipulating group. The procedure used by Huttenlocher with the manipulating group differed from the usual selection procedure in that the array of possible stimulus patterns was not available to the Ss for continuous inspection.

The purpose of the present experiment was to

compare the performance efficiency of the two procedures using fourth-grade Ss and a selection procedure in which the array of possible stimulus patterns was available for continuous inspection.

Method

Subjects. Twenty students, ten male and ten female, enrolled in the fourth-grade of the Laboratory School at Eastern Kentucky University were Ss in this experiment. All Ss were ten years of age, except one, who was eleven.

Materials. The materials used consisted of sixteen wooden blocks, varying in shape and color. Four of the blocks were circles, four were square, four were triangles, and four were crosses. There were four colors of each shape: red, green, blue, and yellow. The blocks were 3.81 cm in length and width, and 1.27 cm in depth.

Procedure. A yoked design was employed. Ten of the Ss were randomly assigned to a Selection Group, and ten to a Reception Group. Each S in the Reception Group was yoked with an S in the Selection Group in that he received instances in the same order as that selected by his yoked counterpart.

Ten problems were presented. The same first two problems were administered to all Ss; these problems served as practice problems and enabled E to insure that Ss understood instructions. The next eight problems were administered, in random order, to all Ss in the Selection Group. The Reception Group Ss received the problems in the same order as their counterpart. The solution for each problem was one value of one dimension; for example, "green" or "circle," or "cross." At the beginning of each problem Ss were shown a positive or negative instance of the concept. Of the eight problems, four had negative examples and four had positive examples.

All Ss were told what attributes defined a concept. Ss in the Selection Group were told to sort the blocks into two columns: one containing all instances of the concept and the other containing all instances that were not the concept. They were also instructed to move only one block at a time. For Ss in the

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Reception Group, the instances were presented successively in the same order as their yoked counterpart had selected them. All Ss were informed if they made an incorrect classification and were instructed to correct their error.

Results and Discussion

Using the trial-on-which-last-error-occurred as a measure of efficiency of concept learning, the results indicated that the reception procedure was superior to the selection procedure, a median of 17 trials for the Reception Group and a median of 26 trials for the Selection Group. Wilcoxon Signed Rank Test showed statistical significance between the two groups (p = .05, two-tailed). Statistical significance was also obtained between the two groups when negative examples of concepts were presented (p = .05, twotailed); no statistical significance was obtained with positive examples. Further analysis showed that with problems in which negative examples were presented, Ss made about twice as many errors than when positive examples were presented. The mean number of errors for Ss in the Selection Group with positive examples of concepts was 3.9, with negative examples, 7.7. A t test for correlated measures between the positive and negative examples was highly significant (t = 4.09, p < .01). For Ss in the Reception Group the mean numbers of errors were 2.8 and 6.4 for positive and negative examples (t = 3.56, p <.01). These results are in agreement with a previous study reported by the Es with college students (3). In that study, however, three times as many errors were obtained with negative examples than with positive examples. Such results would be expected from the logical analysis of the informational contents of this task (4). When presented with a positive example, say a red triangle, S's alternatives are either "red" or "triangle." Using the same block as a negative example, the possible alternatives are "green," "blue," "yellow," "circle," "cross," or "square." Thus

a ratio of 3:1 possible alternatives exists between negative and positive instances.

The possibility of sex differences in concept learning by the two procedures could not be determined in the present study, since males and females were not specifically paired by sex, but in the order of Ss arriving for the experiment.

The results of this experiment imply that learning of simple concepts by children should be more efficient when instances of concepts are presented with a reception procedure rather than with a selection procedure. The reason for this discrepancy in efficiency of learning with the two procedures is still unknown. One possibility might be that the Ss in the Selection Group are faced with a more distracting situation (a display board of different colored blocks and shapes). Ss in the Reception Group are faced with a less distracting task since they make a decision on one block at a time. If this is true, one would expect the discrepancy between the two procedures to increase with increasing difficulty in the concept learning task. Such an investigation is now being conducted.

Summary

The results of the present experiment indicate that learning of concepts was more efficient when instances of concepts were positive and presented successively than when instances were negative and presented simultaneously. These results are in agreement with two previous studies of concept learning: one with seventh-grade children (2) and one with adults (3).

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Folding and Tearing Paper as an Aid to Visualizing Geologic Structures in Three Dimensions

To many students of Earth Science a geologic map may represent a pretty example of abstract art, but often the student is unable to interpret the map pattern and visualize the three dimensional aspects of the structures shown on the map. Since such maps are the basic means by which a geologist assembles his data and makes his preliminary interpretations of an area's structure and stratigraphy, earth science students should have some familiarity with them. However, many students claim that they can not visualize structures in three dimensions and as a result geologic maps and the structures they portray remain a mystery. In this paper we shall deal only with the three dimensional visualization of folds since they are more easily understood by most students than are faulted structures.

A geologic map of an area underlain by folds with horizontal axcs reveals a series of parallel formations which are repeated and the students can easily learn the rule that the oldest beds are in the center of an anticline and the youngest beds are in the center of a syncline. They can then mechanically tell these two folds apart. However, when the fold axes plunge, the map pattern shows a series of hairpin bends in the formations, and the students often become confused. Of course, they can still learn that anticlines plunge in the direction of the "V" or hairpin, and synclines plunge away from it. If they combine this generality with the first one, once again they can tell the synclines from the anticlines. However, can they really visualize what the folds look like in three dimensions, and do they really understand why a particular fold produced the map pattern which it did? The answer to this question is particularly vital to studies of Virginia geology where the conspicuous Valley and Ridge Province is underlain by large plunging folds and the outcrop pattern of resistant and non-resistant formations coupled with subsequent erosion has determined the position of the prominent mountains and intervening valleys.

Perhaps the standard way of helping the student to visualize these folds in three dimensions and relate the geologic map pattern to the folds is to utilize block diagrams. In these, the top of the block is equivalent to the geologic map view, and the sides of the block represent structural cross-sections. Examples of such block diagrams illustrating plunging and non-plunging folds are given in Fig. 1. Unfor-

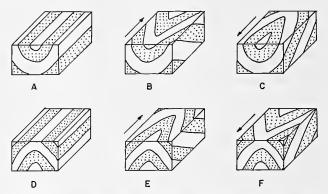


Fig. 1—Block diagrams of folds. A—Syncline with a horizontal fold axis. B, C—Synclines plunging in the directions indicated by the arrows. D—Anticline with a horizontal fold axis. E, F—Anticlines plunging in the directions indicated by the arrows.

tunately, many students may readily accept these block diagrams without ever trying to understand what the folded formations really look like or to comprehend the stages which led to the fold's particular surficial expression.

One of the simplest and least expensive methods to illustrate the development of the map pattern of folded rocks is to utilize several sheets of paper. Not only is this effective to aid in visualization, but the effect of watching the teacher fold and rip sheets of paper seems to act as a stimulus to the students. If the student can follow and understand this simple process, he will not have to memorize the generalities mentioned above but will be able to easily figure out the nature of the folds for himself.

Start with a sheet of paper and fold it into a syncline in which the axis is horizontal (Fig. 2A). Explain that the top view is the geologic map view, the cross-section of the fold is the front view of a block diagram, and the side view is the same as the side view of the block diagram. Surrounding this single rock bed or formation are other units, and the top surface has been worn nearly flat by erosion (Fig. 2B, 2C). The student should be able to see that the outcrop pattern will consist of parallel units on the geologic map view. Similarly, he can see that the front view reveals the true shape of the fold and the side view shows beds which appear to be horizontal. This is often the view which is seen in road cuts or

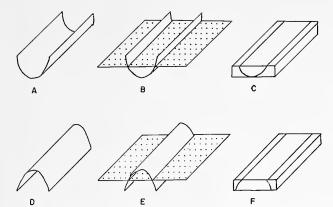


FIG. 2—Stages in illustrating eroded non-plunging syncline and anticline. A—Paper folded into a syncline with a horizontal fold axis. B—Same syncline intersected by an imaginary horizontal plane (stippled) representing the surface to which erosion will truncate the folded beds. C—A block diagram of the folded bed after erosion. D, E, F—The same stages in the development of an eroded anticline.

on cliff faces. Using the same sheet of paper, fold it into a simple anticline (Fig. 2D) and ask the students to try and visualize what the map view would look like after the crest of the fold had been eroded away (Fig. 2E, 2F). They should also be able to understand what the two cross-sectional views would be.

Next, take a sheet of paper, fold it into an anticline, and then tilt the fold so that it plunges toward the students (Fig. 3A). This is how the fold would appear before erosion had truncated its upper surface. The effects of erosion can be rapidly produced by tearing off the paper along a horizontal plane (Fig. 3B, 3C). The students can then immediately see that the outcrop pattern of this folded bed forms a "V" or hairpin which points in the same direction as that in which the fold plunges (Fig. 3D). They can also easily see that one cross-section shows the regular anticlinal shape of the fold while the other

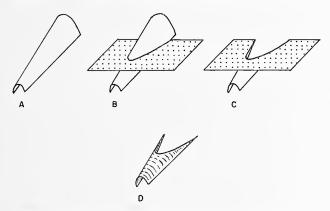


Fig. 3—Stages in illustrating an eroded plunging anticline. A—Paper folded into an anticline and plunging toward you. B—Same anticline intersected by an imaginary horizontal plane (stippled). C—Same anticline after erosion has removed material above the imaginary horizontal plane (stippled). D—The folded paper with the imaginary horizontal plane removed.

reveals a bed which is inclined in the direction in which the fold plunges. From this folded and torn sheet of paper the corresponding block diagram can readily be constructed. At the same time, the relative ages of the beds in the structure can be pointed out very simply. Just to convince the students that this really works you could do it again but have the fold plunging toward you instead.

The same basic steps are repeated to produce a plunging syncline in map pattern and cross-section (Fig. 4A, 4B, 4C). Here the students can see that the fold plunges away from the "V" in the map pattern and that on the side cross-section the trace of the beds will still be inclined in the direction in which the fold is plunging (Fig. 4D). Once again, the appropriate block diagram can easily be constructed.

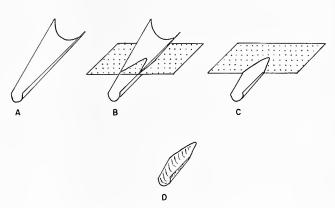


FIG. 4—Stages in illustrating an eroded plunging syncline. A—Paper folded into a syncline and plunging toward you. B—Same syncline intersected by an imaginary horizontal plane (stippled). C—Same syncline after erosion has removed material above the imaginary horizontal plane (stippled). D—The folded paper with the imaginary horizontal plane removed.

As a finale, with a little dexterity it is possible to bend a sheet of paper into an anticline bounded by two synclines or a syncline bounded by two anticlines. After tilting these structures and simulating erosion by tearing off the excess paper, the synthetic map view will show a striking similarity to a geologic map of portions of the Valley and Ridge Province in Virginia. A block diagram could also be constructed from this model.

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TEACHERS!!

Do you have a question that you'd like answered? Do you have a favorite demonstration, method of getting across a concept, or an experiment that you'd like to share with others?

Do you have a technical article that you'd like to have published?

Are you involved in a program, a course of study, or an activity which you think would be of interest to other educators?

Would you like to analyze or give a critical evaluation of a curriculum, talk, article, or book?

Would you like to do a little philosophizing?

GREAT NEWS—NOW IS YOUR CHANCE!!

The editor of the Virginia Journal of Science plans to devote a page or two in each issue to items written especially for junior and senior high school teachers of science and mathematics. We are now soliciting contributions which will be of interest to teachers and which will be of value in furthering scientific and mathematical education in the state.

Send your contributions to Virginia C. Ellett, Mathematics and Science Center, 2200 Mountain Road, Glen Allen, Virginia 23060. Do this right away so that they may appear in the next issue of the Journal, but don't stop here. Let this be the beginning of many articles from you. Remember this is YOUR section and its success depends upon your contributions.

VIRGINIA ACADEMY OF SCIENCE

1971 Meeting

Virginia Polytechnic Institute and State University Blacksburg, Va. May 11–14, 1971

1972 Meeting

Virginia Military Institute Washington and Lee University Lexington, Va. May 2–5, 1972

1973 Meeting

50th Anniversary College of William and Mary Williamsburg, Va. May 1-4, 1973

1974 Meeting

Old Dominion University Virginia Wesleyan College Virginia State College Norfolk, Virginia April 30–May 4, 1974

1975 Meeting

Madison College Harrisonburg, Va. May 6–9, 1975

Communications and Reports

VIRGINIA ACADEMY OF SCIENCE

Summary of Council Meeting* November 1, 1970

Council met on Sunday, November 1, 1970, in Richmond at the Medical College of Virginia, Virginia Commonwealth University, President Rowe presiding. Minutes of the last Council meeting and minutes of the last Executive Committee were distributed and approved. The President-Elect, Dr. Turner, reported on mailing of a Call for Papers to all members. Dr. Harshbarger suggested that a letter be sent to all college Presidents soliciting papers for the Horsley Award.

Virginia Museum of Science

Dr. Hughes and Mr. Rowe reported on the latest information concerning the Virginia Museum of Science. President Rowe indicated that the Governor has made his decision with respect to the Trustees of the Museum (Editor's note: see News and Notes Section). Dr. Hughes mentioned that there is still a Museum of Science Committee of the Academy.

Acceptance of New Bylaws

Jim Midyette proposed acceptance of the new bylaws which have been distributed to all members of Council. Dr. Harshbarger raised the question of downgrading of the Section Editors and felt that these were important. A rather vigorous discussion followed in which it was mentioned that sections could do what they wished with respect to Section Editors and that their role in an active section might be a worthy one. The bylaws were accepted with a few minor modifications primarily editorial in nature and the addition of a statement concerning the Virginia Flora Committee as a standing committee of the Academy. They are published with the Constitution in this issue of the *Journal*.

Executive Secretary's Office Facilities

Mr. Blanton Bruner reported that his new office at the Virginia Institute of Scientific Research is a rather small one but that it is adequate for the time being. He and Rodney Berry will have completed their transfer of duties by January 1, 1971. There is an answering service at the VISR so that anyone needing to call Mr. Bruner can do so at the VISR number. Mr. Morrow asked about the archives and Mr. Bruner reported, and Mr. Berry confirmed, that they do not presently know the whereabouts of any archives. Dr. Harshbarger commented that Mr. Bruner should express whatever needs he has to the Executive Committee. Dr. Carpenter suggested that

the History of the Academy Committee or any persons interested in the history of the Academy might find the Past Presidents' Correspondence quite useful. Flint reported that he had consulted with Marjorie Harris concerning any materials Isabel Boggs may have left with her which were concerned with the history of the Virginia Academy of Science. Miss Boggs had not left any materials which belonged to the Academy.

Academy Fellows

Dr. Carpenter read the minutes of September, 1969, concerning Academy Fellows. The Chairman of the Awards Committee will put in the next issue of the *Journal* a statement concerning nominations for Academy Fellows and Dr. Turner will send information concerning nominations in his Call for Papers to the entire Academy membership.

Formation of Institute for Ecological Research and Teaching Purposes

Dr. Hughes gave a brief outline of an idea which he and others are working with for the development of an organization which would be effective in emphasizing human ecology within the state of Virginia. Dr. Brooks moved and Dr. Carpenter seconded a motion that the Council express its support in principle for the concept of a private statewide institute for ecological research and education. This motion was passed without dissent.

Governor's Science Advisor

Dr. Harshbarger moved the proposal by the Executive Committee to nominate Dr. Siegel, Dr. Carpenter, and Dr. Turner to the Governor for his appointment as Science Advisor. This motion passed.

Abolishment of Registration Fees

There was discussion concerning raising of dues and doing away with registration fees. At the present time approximately \$1800 comes from registration. If we have no registration fee, dues will have to be increased to raise this money. There are a number of people who come to the annual meeting who are not members of the Academy. They pay registration fees and then are invited to join the Academy after the meeting. We will retain registration fees. There was some discussion about allowing only persons with a badge into the paper sessions. Dr. Morrow indicated that it might not be feasible to have guards at the door to keep people out who have not paid registration fees.

Future Annual Meetings

Dr. Carpenter reported Annual Meetings for 1971, '72, '73, '74, and '75. He proposed that the invitation of Madison College be accepted and the dates

^{*} Abbreviated by the Editor from minutes provided by the Secretary, Franklin F. Flint.

for this meeting be May 6–9, 1975. Concerning the 1971 meeting, Dr. Harshbarger mentioned that VPI has a policy of charging for certain rooms in the Student Center. It was suggested that President Rowe initiate correspondence immediately to see that these rooms are offered free of charge.

Visiting Scientists Program

President Rowe reported that announcements have gone to the Presidents of various colleges asking for volunteers for the Visiting Scientists Program to the high schools. Dr. Alex M. Clarke, director, is considering using some outstanding Virginia scientists for development of tapes to be placed on Educational Television in the Richmond area. Some members of Council expressed a desire that this be done but that the quality of the performers be checked ahead of time and only the best be used. Dr. Morrow moved that Council support this program. This motion passed.

Finance Committee

Dr. Harshbarger suggested that the budget be cut to meet established income. There was a vigorous discussion concerning the development of a reserve fund and its possible use to balance the current budget. Mr. Berry mentioned that over the past seven years reserve funds have built up to a considerable extent. Mr. Midyette moved and Dr. Campbell seconded a motion that the Finance Committee Report be amended so that the budget can be balanced from reserve funds this year, if need be. This was necessary so that the Virginia Junior Academy of Science budget can be maintained at the requested level. The motion passed.

Long Range Planning Committee

Dr. Ulrich reported on four main items: interest of the Committee in textbook selection and concern that the Science Teachers Section do something about this; the best manner for affiliating junior college people into our program; and the lack of involvement of the mature and most prestigious senior scientists within the state. Fourthly, they are studying the effects of section proliferation.

Membership Committee

Mr. William Young reported on plans for personal solicitation of new members through correspondence. A considerable number of letters have been sent out and the Committee requests members to suggest persons who should be solicited for membership.

Virginia Flora Committee

Dr. Harvill reported the Committee is soon to take a foray into the Dismal Swamp, and all members of Council were invited to join them. There was no obvious rush to do so.

Virginia Journal of Science

Lynn Abbott reported that lists of exhibitors, fellows and new sections have been published in the *Journal*. He also reported selection of a new business manager, Dr. Charles E. O'Rear.

Conservation Committee

Dr. Hughes expressed concern over scenic Virginia along the James River. The situation is causing local concern over proposed building of bridges and other construction. The Committee was asked to examine the facts and report them to the Executive Committee.

Nominating Committee

Dr. Carpenter as Chairman of this Committee asked that members submit names to him of persons they would like to see nominated as officers of the Academy.

Decision of Internal Revenue Service

Mr. Berry reported that the Internal Revenue Service has sent him a letter stating that on October 20, 1970, the Virginia Academy of Science was classified as an organization and that it is not a private foundation as defined in Section 509(A) of the Internal Revenue Code. This is an organization that normally receives no more than ½ of its support from gross investment income and more than ½ of its support from contributions, membership fees and gross receipts from activities related to its exempt functions subject to certain exceptions Section 509(A) 2.

BYLAWS OF VIRGINIA ACADEMY OF SCIENCE

(Approved by Council November 1, 1970)

ARTICLE I: TYPES OF MEMBERSHIP AND DUES

- Section 1. There shall be eight types of members; regular, student, contributing, sustaining, life, patron, honorary life, and business.
- Section 2. Dues of the first 4 types of members shall be as follows:
 - (1) Regular members shall pay annual dues of five dollars (\$5.00).
 - (2) Student members shall pay annual dues of three and one-half dollars (\$3.50).
 - (3) Contributing members shall be members who elect to pay annual dues of ten dollars (\$10.00).
 - (4) Sustaining members shall be individuals and institutions who elect to pay annual dues of twenty-five (\$25.00) or more.
 - (5) To be in good standing the foregoing types of members must not be in arrears on payment of dues for more than one year, provided, however, any member not in good standing may be reinstated upon payment of Regular or Student membership dues, as the case may be, for the preceding year.
- Section 3. Life members shall be individuals who elect to pay to the Academy the sum of one hundred and fifty (\$150.00) and thereby become exempt from further payment of dues.
- Section 4. Patrons shall consist of those persons who have given to this organization the sum of one thousand dollars (\$1,000.00) or its equivalent in property. They shall have all the rights and privileges of regular members and shall be exempt from dues. An institution may also become a patron by meeting the above requirement. Its representative shall have all the rights and privileges of regular members.
- Section 5. Honorary life members shall consist of persons elected by the Council for long and distinguished service to science in this organization and others no matter where located. They shall have all the rights and privileges of regular members and shall be exempt from dues.
- Section 6. Business or industrial organizations, which pay dues of \$100.00 annually, shall be Business Members of the Academy.

ARTICLE II: DUTIES OF OFFICERS

- Section 1. The President shall be the directing head of the Academy, shall preside at business meetings and general sessions of the organization, and shall appoint the members of the standing committees and of new committees authorized by the Council, in accordance with Article XI of the Constitution.
- Section 2. The President-Elect shall assist the President as mutually agreed between them, shall serve as president in the latter's absence, and shall be responsible for coordinating the scientific programs of the Annual Meeting. He shall furnish the Academy at its Annual Conference with a list of committee memberships which he has set up to assist him during his year as President.
- Section 3. The Secretary shall be responsible for keeping complete records of the Academy Conference and all meetings of the Council and Executive Committee.
- Section 4. The Treasurer shall:
 - A. Account for the income and disbursements through one Academy General Fund Account.
 - B. Keep the membership lists of the Academy up-to-date.
 - C. Upon request, supply the Secretary and others a list of all members in good standing.
 - D. Receive and disburse all funds as approved by Council and directed by the President or Chairman of the Finance Committee.
 - E. Submit to Council annually a written report of all receipts and disbursements, accompanied by a statement of audit from a certified public accountant.
 - F. Furnish quarterly financial summaries to the Executive Committee, members of Council, and to members of the Finance Committee.
 - G. Prepare annually and present to the Finance and Endowment Committee for review a proposed budget for Academy operations.

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- Section 5. The Treasurer and all administrative employees engaged in the receipt and disbursement of funds shall be adequately bonded.
- Section 6. All officers shall be ex-officio members of all Academy Committees.

ARTICLE III: DUTIES OF STANDING COMMITTEES

- Section 1. Research Committee shall:
 - (1) Review and award Academy Research Grants.
 - (2) Arrange for and present the J. Shelton Horsley Research Award.
- Section 2. Long Range Planning Committee shall:
 - (1) Develop and advise Council on broad policies which will affect the Academy in the future.
 - (2) Solicit and study suggestions from the membership for the improvement of Academy activities.
 - (3) Investigate and evaluate proposed projects, publications and other factors that may relate to the long-range effectiveness of the Academy.
 - (4) Advise and consult with other Academy Committees relative to the aforegoing and make recommendations to such committees concerning the effectiveness of their various activities.
- Section 3. The Junior Academy of Science Committee shall:
 - (1) Provide Director for Junior Academy of Science.
 - (2) Coordinate activities of Junior Academy of Science including annual meeting.
 - (3) Prepare V.J.A.S. budget and submit to V.A.S. Finance Committee by September 1.
 - (4) Prepare National Science Foundation proposal and submit to Executive Committee by October 1.
 - (5) Publish and distribute Proceedings of V.J.A.S. by October 1.
 - (6) Select two student representatives to attend American Junior Academy of Science.
 - (7) Solicit membership and participation in Junior Academy programs and projects.
 - (8) Select students for V.A.S. and A.A.A.S. Honorary Membership Awards.
 - (9) Select recipient of Outstanding Science Teacher Award.
 - (10) Select recipient of V.J.A.S. Distinguished Service Award.
 - (11) Select students to present papers to Senior Academy Sections.
 - (12) Support and participate in all other programs and activities related to the work of V.J.A.S.
- Section 4. Membership Committee shall:
 - (1) Make recommendations to Council, the Executive Committee and officers relative to policies on general membership.
 - Promote membership growth and seek adequate representation from all scientifie disciplines.
 - (3) Sponsor a Business Advisory Committee for the purpose of creating understanding between science and business, and to solicit business memberships to the Academy.
- Section 5. Finance and Endowment Committee shall:
 - (1) Monitor and appraise income and expenditures, and make appropriate recommendations to the President, Executive Committee and Council.
 - Estimate annually the anticipated income of the Academy and prepare a proposed budget for consideration by Council at its Fall meeting.
 - (3) Seek and encourage the establishment of endowments to the benefit of Academy activities.
- Section 6. The Trust Committee shall:
 - Hold in trust and manage funds of the Academy designated by Council or otherwise for
 - Review all Academy investments annually and make appropriate adjustments subject to approval of Council.
- Section 7. The Publications Committee shall:
 - (1) Develop and implement a continuing policy of review and evaluation of Academy publications.
 - Present to Council annually through the Finance Committee the budgetary needs of the several Academy periodical publications.

 (3) Make recommendations to Council relative to priority, publication, finance and distribution
 - of non-recurring publications.
 - (4) Select and recommend to Council, as necessary; an Editor for The Virginia Journal of Science, and members of the Editorial Board.
 - (5) Enlist the interest of all groups in worthwhile publications by the Academy.

- Section 8. The Awards Committee shall:
 - (1) Select recipients of the Ivey F. Lewis Distinguished Service Award to be presented periodically to a member who has made significant contributions toward the activities of the Virginia Academy of Science.
 - (2) Select recipients of Special Awards periodically as directed by Council.
 - (3) Accept and submit to Council nominations for fellows in accordance to Article V of the Constitution and Article V of the Bylaws.
- Section § 9. The Fund Raising Committee shall from time to time at the direction of Council, plan, organize, and coordinate appropriate fund raising campaigns in support of Academy activities or projects contingent to the purposes of the Academy.
- Section 10. The Nominating Committee shall:
 - (1) Solicit suggestions from Council members, Past Presidents and others for the names of persons to fill the offices of President-Elect, Secretary and Treasurer.
 - (2) Contact prospective nominees and obtain from each a commitment to serve if elected.
 - (3) Present to the Annual Academy Conference a slate of nominees and the qualifications of each.
- Section 11. The Science Talent Search Committee shall:
 - (1) Canvass colleges and universities for scholarships available to Science Talent Search Finalists.
 - (2) Forward list of available scholarships to all high school sponsors that have requested applications for the Westinghouse Science Talent Search.
 - (3) Secure list of Virginia contestants from Science Clubs of America and establish a committee to select best 45 papers.
 - (4) Set up procedures for selecting the top 15 students and declare and announce them to be State Winners in the Virginia Science Talent Search, and all other contenders as runners-up.
 - (5) Send names of winners and runners-up to colleges and universities in Virginia.
- Section 12. The Constitution and Bylaws Committee shall:
 - (1) Periodically receive and prepare drafts of all proposed changes in constitution as the occasion arises and present same to Council and membership for consideration as set forth in the constitution.
 - (2) Draft all bylaw changes as directed by Council and notify membership of such changes.
 - (3) Update articles of Incorporation (Charter) as required.
 - (4) Provide a Parliamentarian for all Council meetings and Academy Conferences.
- Section 13. The Virginia Flora Committee shall:
 - (1) Promote the study of and publications on the flora and vegetation of Virginia.
 - (2) Sponsor symposia and conferences on the ecology, conservation, and preservation of the plant life of Virginia.
 - (3) Disseminate botanical information to all who are interested in the flora and ecology of Virginia.
 - (4) Serve as liaison between the Academy, government bodies, and institutions in matters pertaining to the plant life of Virginia.

ARTICLE IV: VIRGINIA JOURNAL OF SCIENCE

- Section 1. The Academy shall publish the Virginia Journal of Science quarterly.
- Section 2. The staff of the Virginia Journal of Science shall be composed of:
 - (1) An editor recommended by the Publications Committee and appointed by Council for a three-year term.
 - (2) Such Associate Editors, Assistant Editors, or Editorial Board members, appointed by the President, as are recommended by the Editor and the Publications Committee.
 - (3) Editors designated by individual Sections.
- Section 3. All members of the Academy shall receive the Virginia Journal of Science.
- Section 4. Subscriptions may be sold to non-members at a rate established by the Publications Committee and approved by Council.

ARTICLE V: RULES AND PROCEDURES FOR SELECTING FELLOWS

Section 1. A "Fellow" must be nominated by at least three members of the Academy. The Academy Council must approve each Fellow by a majority vote, and establish a limiting date annually for receipt of nominations. It will be the usual procedure to annuance new Fellows at an Annual Meeting.

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- Section 2. No more than twenty-five fellowships will be approved the first year. After the first year, no more than one-half of one percent of the total active membership shall be selected in any one year. The limiting number of Fellows shall not exceed five percent of the total active membership of the Academy.
- Section 3. All Fellows shall be presented with a suitably inscribed scroll.
- Section 4. Appropriate announcement of new Fellows shall be made in the Virginia Journal of Science.

ARTICLE VI: THE DULY ORGANIZED SCIENTIFIC SECTIONS OF THE ACADEMY ARE:

(1) Agricultural Sciences

(2) Astronomy, Mathematics and Physics

(3) Microbiology

(4) Biology

(5) Chemistry

(6) Materials Science

(7) Engineering

Geology Medical Sciences (9)

(10) Psychology

(11) Science Teachers

(12) Statistics

(13) Space Science and Technology

(14) Botany

ARTICLE VII: OFFICIAL REPRESENTATION OF THE ACADEMY

Where official representation of the Academy is desirable the President or his designates shall represent the Academy. No officer or other Academy member shall receive reimbursement from Academy funds for such purposes, except that actual expenses of the Academy representatives in attending the annual meeting of the American Association for the Advancement of Science may be paid, subject to the funds provided in the budget by the Finance Committee.

ARTICLE VIII: MEETINGS AND BUSINESS

The annual meeting of this organization shall be held during the first or second week of May each year at a place selected by Council, which shall also determine whether the annual meeting shall be held the first or second week of May, and arrange for all appropriate sessions.

CONSTITUTION OF THE VIRGINIA ACADEMY OF SCIENCE

(Adopted May, 1970)

ARTICLE I: NAME

The name of this organization shall be the Virginia Academy of Science.

ARTICLE II: PURPOSE

The purpose of this organization shall be to establish and maintain in Virginia for scientific and educational purposes an association of persons and organizations interested in science and scientific research in all of its branches; to solicit financial and other support; to cooperate with educational institutions, industries, and state agencies in fostering an interest in scientific matters, in promoting scientific investigations and in spreading knowledge of the sciences; to provide a forum for the presentation and discussion of papers on scientific subjects and facilities for their publication; to provide opportunities for the cooperation and fellowship among its members; and generally, in doing these things, to benefit not only its own members, but to promote the civic, agricultural, academic, industrial and commercial welfare of the people of Virginia.

ARTICLE III: ORGANIZATION

Section 1. Membership

Membership in this organization shall be open to professional scientists of all branches of science and others who are interested in the purpose of the organization. Types of membership and dues for each shall be specified in Academy Bylaws. The membership, through the Academy Conference, provided by Section 2 of Article VIII, shall have ultimate authority over the affairs of this organization.

Section 2. Sections

The Academy shall be organized into sections according to the various scientific disciplines. A person may belong to one or more sections in accordance with his interests.

Section 3. Council

The governing body of this organization shall be the Academy Council. Its composition and responsibilities are specified in Article VII.

Section 4. Officers

The elected officers of this organization shall be a President, a President-elect, a Secretary, and a Treasurer. Duties of each shall be specified in Academy Bylaws.

Section 5. Executive Committee

The elected officers and the immediate past presi-

dent shall comprise the Executive Committee of the Academy Council.

Section 6. Standing Committees

The primary activities of this organization shall be implemented by Standing Committees as follows: The Research Committee, the Long Range Planning Committee, the Junior Academy of Science Committee, the Membership Committee, the Finance and Endowment Committee, the Trust Committee, the Publications Committee, the Awards Committee, the Fund Raising Committee, the Nominating Committee, the Science Talent Search Committee, the Virginia Flora Committee, and the Constitution and Bylaws Committee; the duties of the Standing Committees not specified hereafter, shall be as specified in the Academy Bylaws, and as may be further enumerated by Council from time to time.

ARTICLE IV: THE VIRGINIA JOURNAL OF SCIENCE

The *Virginia Journal of Science* shall be the official publication of the Virginia Academy of Science. All Academy members shall receive copies of this publication.

ARTICLE V: FELLOWS

From active membership, there shall be a body of scholars known as "Fellows of the Virginia Academy of Science" selected because of their contribution to science in one or more of the following ways: (a) outstanding scientific research, (b) inspirational teaching of science, (c) significant leadership in the Academy. Rules and procedures for selection of Fellows shall be specified in the Academy Bylaws.

ARTICLE VI: ACCREDITATION OF MEMBERSHIP

Membership of the Academy shall be accredited by the Secretary and the Treasurer. The membership list shall be published periodically according to types, as directed by Council.

ARTICLE VII: COMPOSITION AND RESPONSIBILITIES OF COUNCIL

Section 1. Council shall be composed of the President, the President-elect, the Secretary, the Treasurer, the three most recent Past Presidents and one member elected by each Section of the Academy. Members from the Sections shall be elected for three year terms on a rotational basis among the Sections, provided the initial term of a member from a newly established Section shall be

specified by Council. In addition to the foregoing, the Chairmen of the Standing Committees and the Editor of the *Virginia Journal of Science* shall be ex-officio members of the Council. In event of vacancies, the President shall make interim appointments until the next election is held, provided, however, vacancies of elected officers shall be filled as hereafter provided.

Section 2. Council shall meet each year preceding the annual meeting and at least once in the fall at a time and place designated by the President.

Section 3. Twelve members shall constitute a quorum for the transaction of business by Council.

Section 4. Council shall establish the policies of this organization and shall be responsible for the administration of all Academy funds.

Section 5. Council shall consider and recommend to the membership from time to time appropriate changes in the Constitution, and shall promulgate bylaws appropriate to the implementation of the Constitution.

Section 6. Council may establish appropriate administrative positions and employ such personnel as may be required. Terms of office, the duties and remuneration of such personnel shall be prescribed by Council.

Section 7. Through appropriate Bylaws, Council shall provide for the publication of the *Virginia Journal of Science*.

Section 8. The Executive Committee of Council shall be empowered to act for Council on an interim basis between meetings of Council and shall report to Council at its regular meetings. A meeting of Council may be called at any time upon concurrence of any four members of the Executive Committee.

ARTICLE VIII: MEETING AND BUSINESS

Section 1. The annual meeting of this organization shall be arranged in accordance with procedures to be established by Council in appropriate Academy Bylaws.

Section 2. All business requiring action by the membership shall be transacted at an Academy Conference which shall be scheduled by Council during the annual meeting. A meeting of the Academy Conference may be called between Annual Meetings by concurrence of a majority of the members of Council, provided, however, that the membership shall be notified of such called meeting no less than 30 days prior to the date that such meeting is to be held. Forty accredited members shall constitute a quorum for the transaction of business by an Academy Conference.

Section 3. Each Section shall annually arrange a program oriented to its area of scientific interest; provided, however, such programs shall be compatible with the purposes of the Academy and

scheduled within the framework of the general meeting program of the Academy.

Section 4. The fiscal year of the Academy shall be from January 1 through December 31.

Section 5. The parliamentary procedure for all meetings of this organization shall be governed by Robert's *Rules of Order* Revised, and Council shall provide for a Parliamentarian.

ARTICLE IX: ESTABLISHMENT OF SECTIONS

Section 1. Sections as defined in Article III with the approval of Council, may be organized by an accredited group of members. Each Section shall annually arrange a scientific program related to its area of interest.

Section 2. Such a Section may become accredited and established after it has conducted one successful program at an annual meeting of the Academy.

Section 3. Any Constitution and Bylaws proposed by a Section must conform to the provisions of the Academy Constitution and Bylaws and shall be submitted to Council for review and approval prior to adoption by Section.

Section 4. Any Section which fails to conduct a program at two successive Academy annual meetings may be dropped as a Section by action of Council, but may be reinstated after subsequently conducting one successful program.

Section 5. When established, all Section names shall be enumerated in the Academy Bylaws, and thereby subject to provisions of Article XIII, Section 1.

ARTICLE X: ELECTION OF ACADEMY AND SECTION OFFICERS

Section 1. A Nominating Committee, consisting of three recent Past Presidents, appointed by the President, shall submit to the Annual Academy Conference, nominations for President-elect, Secretary and Treasurer. Nominations from the floor shall be in order. Those nominees receiving a majority assenting vote at the Academy Conference shall be elected.

Section 2. Upon election, such officers shall serve one year terms; however, the President-elect shall automatically ascend to the presidency at the end of his scheduled term of office or at any prior time that the office of president may be vacated; however, he shall not succeed himself as president after serving his scheduled term of office.

Section 3. All vacancies in Academy offices, other than president, occurring between annual Academy Conferences, shall be filled by Council from names of persons recommended by the Executive Committee. Persons so selected shall serve until the next Academy Conference.

Section 4. Each Section shall elect from their members:

a. A Chairman, and a Secretary for one year terms of office.

 A representative to Council in aecordance with the provisions of Article VII.

c. Other officers desired.

Section 5. Persons to fill vacancies in Section offices which occur between Annual Meetings shall be designated by the Council Representative from the Section.

Section 6. All elected officers shall serve without remuneration, but, at the discretion of Council, may be reimbursed for certain expenses incurred in conducting the business of the Academy.

ARTICLE XI: COMMITTEE STRUCTURE, APPOINTMENTS, TERMS, ETC.

Section 1. Except as provided otherwise, all Standing Committees shall be composed of 3 or more members, and the President shall designate Committee Chairmen, and appoint approximately one-third of the members of each Committee for terms of 3 years, and shall subsequently appoint members to fill unexpired terms that occur periodically.

Section 2. The Research Committee shall be composed of five (5) members, each appointed for a term of five (5) years. One new member shall be appointed each year by the President to replace the member whose term expires; unexpired terms shall also be filled by appointment by the President. The senior member of the Committee shall be Chairman.

Section 3. A Trust Committee, composed of three accredited members, shall be elected by Council, to serve for terms of three years on a rotational basis. The members of this Committee shall hold in trust and manage Academy investments subject to annual approval by Council. The Committee shall elect its own Chairman; provided, however, that should it be unable to do so, the President shall name the Chairman.

Section 4. The President and Council shall assign operational matters to appropriate Standing Committees; however, the President and/or Council may establish Special Committees as the need arises.

ARTICLE XII: JUNIOR ACADEMY OF SCIENCE

The Academy shall provide financial support, leadership, and supervision to a Junior Academy of Science. Effective working relationships shall be maintained with such Junior Academy of Science, through the Junior Academy of Science Committee.

ARTICLE XIII: BYLAWS AND AMENDMENTS

Section 1. Council shall promulgate appropriate

Bylaws to implement or further clarify the Articles of this Constitution. The establishment or amendment of such Bylaws shall require an affirmative vote of a majority of the total membership of Council; provided, that all proposed Bylaws or amendments shall be distributed to the membership or published in an issue of the *Virginia Journal of Science* at least 30 days prior to action by Council.

Section 2. This Constitution may be changed or amended, after the recommendation of a majority of the total membership of Council, by a two-thirds majority of an Academy Conference, provided all proposed changes shall be submitted to members of Council in writing no less than 15 days prior to the Council meeting at which such proposals are to be considered and further provided that subsequent to approval by Council, all proposed amendments shall be published in the *Virginia Journal of Science* or distributed in writing to the membership no less than 25 days nor more than 50 days prior to the presentation to an Academy Conference for adoption.

Section 3. All provisions of the Constitution and Bylaws in effect prior to the adoption of this Constitution, except the provisions of this Article, shall rule until new Bylaws are duly established in accordance with Section 1 of this Article.

ARTICLE XIV: ARTICLES OF INCORPORATION

The Articles of Incorporation of this Organization (Charter) shall conform to the provisions of this Constitution and all amendments hereafter adopted. The Constitution and Bylaws Committee shall review and coordinate all necessary appropriate revisions of both documents and be responsible for the submission of all required reports to the State Corporation Commission and other governmental entities, annually or as otherwise required by law.

ARTICLE XV: DISSOLUTION OR LIOUIDATION

Section 1. In the event of dissolution or liquidation, all liabilities and obligations of the Academy shall be paid, satisfied and discharged.

Section 2. All assets remaining, including those received and held for scientific and educational purposes, shall be transferred to one or more societies or organizations engaged in activities substantially similar to those of the Academy; provided however, that no assets shall accrue to the benefit of any officer or member of the Academy.

Prepared by the Constitution and Bylaws Committee James W. Midyette, Jr., Chairman Addison D. Campbell William B. Wartman

News and Notes

HARRIETT H. FILLINGER

Miss Harriett H. Fillinger, 80, former professor and chairman of the department of chemistry at Hollins College, died December 26, 1970, in Oak Ridge, Tennessee.

Miss Fillinger was a charter member of the Virginia Academy of Science and a fellow of the American Association for the Advancement of Science and of the American Institute of Chemicals. She was a member of the American Chemical Society and of Sigma Xi. She was active in the American Association of University Women.

Miss Fillinger was a native of Bristol, Virginia and received the B.S. degree from the University of Chicago where she also earned an M.S. degree. Before joining the Hollins faculty, where she was from 1921 to 1956, she taught at Sullins College and Mississippi Synodical College. She was lecturer in chemistry at Clinch Valley College of the University of

Virginia from 1956 to 1960.

Miss Fillinger published a number of articles in her field and the widely used laboratory manual, "Experiments in General Chemistry for Colleges." She was recognized at the 1967 dedication of Hollins' new science building, when the Harriett Huldah Fillinger General Chemistry Laboratory was dedicated in her honor. Her former students also had presented her portrait to Hollins. The family requested that remembrances be in the form of gifts in Miss Fillinger's name to be sent to the Hollins College Scholarship Fund at Hollins College, Virginia, 24020.

Surviving her are her sister, Mrs. Richard I. Rush and her nephew, Richard M. Rush, his wife and children, all of Oak Ridge, Tennessee.

ALDEN CRATER

A crater on the dark side of the moon has been named for the late Dr. Harold Lee Alden, former professor of astronomy and director of the Leander McCormick Observatory at the University of Virginia.

Alden Crater is one of some 500 craters recently designated by the International Astronomical Union with names of deceased men and women of science from all over the world. Included in the list of new craters are the names of three American astronauts killed in the Apollo fire, distinguished scientists such as Nobel, Curie, and Pavlov and writers such as Jules Verne and H. G. Wells.

Dr. Alden received his Ph.D. from the University of Virginia in 1917 and taught astronomy there until 1925. For the next 20 years he directed Yale

University's Observatory in Johannesburg, South Africa. He returned to the University in 1945 as professor of astronomy and director of the McCormick Observatory and remained until his retirement in 1960. He died in 1964. Dr. Alden was best known for his work in proper motions, orbits and mass ratios of stars and stellar parallaxes, a method for determining distances of stars from earth.

Not far from the Alden Crater is one named for Dr. William Chauvenet, a mathematician who was instrumental in establishing the U.S. Naval Academy and who was chancellor of Washington University in St. Louis, 1862–1869. His grandson, the late Louis Chauvenet, made his home in Charlottesville.

COMPUTER FACILITY

Three Lynchburg area colleges will share in a \$150,000 National Science Foundation grant for computer equipment and programs to serve their academic needs. The new computer facilities will be added to the Educational Computer Center which is operated jointly by Lynchburg College, Randolph-Macon Woman's College and Sweet Briar College. The center has been serving administrative and limited instructional needs for the three institutions since early in 1967. The NSF grant will enable the colleges to establish a time sharing capability on the three campuses. Each campus will have three remote terminals, each terminal with its own teletype unit which will permit students and faculty to communicate directly with a computer at the center. A portion of the funds will be used for a faculty training program to expedite further curriculum development and academic use of the new facilities. A recent survey of the faculties of the three colleges produced an estimate that some 3000 students from 24 departments would spend about 20,000 hours to meet planned academic requirements during the first year of operation.

VCU SIGMA XI

The first meeting of the newly formed Virginia Commonwealth University chapter of the Society of Sigma Xi was held at the Richmond Academy of Medicine in Richmond on November 18, 1970. The executive board of the society voted last summer to change the chapter's name from MCV chapter to Virginia Commonwealth University to include Sigma Xi members at MCV, the Health Sciences Division of VCU, and members of the VCU Academic Center.

Dr. David M. Hume, professor and chairman of the Department of Surgery at the Medical College of Virginia, spoke on "Achievements and Potential of Organ Transplantation." Dr. Hume is known internationally as a pioneer in kidney transplants in man. He is a member of Sigma Xi and The Virginia Academy of Science.

ANNUAL BURGER LECTURE

Dr. Dereck Harold Richard Barton, professor of organic chemistry at Imperial College, London, and a Nobel laureate in chemistry, presented the annual Burger Lecture "Some Approaches to the Synthesis of Tetracyclines" at the University of Virginia on January 8. Dr. Barton was cowinner of the 1969 Nobel Prize for Chemistry for his work on conformational analysis, which permits chemists to tell from the shape of organic compounds how they will react and what the preferred products of reaction will be. He received his bachelor's degree from Imperial College in 1940, his Ph.D. in 1942 and a D.Sc. in 1949 from the University of London. He has visited this country frequently and has taught at Harvard University, Massachusetts Institute of Technology and the universities of Illinois and Wisconsin.

The Burger Lecture was established in 1964 under the sponsorship of the University Alumni Fund and the Department of Chemistry of the University of Virginia. It is named in honor of Dr. Alfred Bur-

ger, professor emeritus of chemistry.

MATERIALS SCIENCE COLLOQUIA

The Materials Science Department of the University of Virginia has announced the fifth annual Materials Science Colloquia Series for 1970–1971. These Colloquia are supported financially by the Research Laboratories for the Engineering Sciences and are devoted to fundamental aspects of research in materials science. Meetings are held on Wednesdays at 3:30 p.m. in room A 120 Thornton Hall and are open to the scientific public. The schedule for the remainder of 1971 is as follows.

April 14: "Impurity Atom Effects in Metals"
Professor Joseph R. Beeler, Jr., N. C. State University

April 28: "Electronic Structure of Solid-Solution Alloys"

Professor Leonid V. Azaroff, University of Connecticut

May 5: "Crystallography of Martensitic Transformations"

Professor C. Marvin Wayman, University of Illinois

WILLIAM AND MARY VISITING BIOLOGISTS

Colleges in the Virginia area with students interested in pursuing a graduate studies program in biology are invited to request a William and Mary Visiting Biologist. Seminars will be presented to inform interested faculty and students of the current research programs in the Department of Biology in order to promote communications and to stimulate interest in graduate study in the biological sciences, particularly with regard to the opportunities for graduate study at the College of William and Mary. Correspondence concerning specific topics should be directed to the Program Coordinator, Dr. Martin C. Mathes, Department of Biology, College of William and Mary, Williamsburg, Virginia 23185, telephone 229-3000, ext. 240.

SUMMER ECOLOGY INSTITUTE

A summer ecology institute, aimed primarily at high school biology teachers from the Appalachian region, will be held June 21 to August 13, 1971, at Radford College. Weekday classes will include lectures, discussions, and field trips. A three-day trip to the Savannah River Ecology Laboratory in South Carolina also is planned. The course is limited to 35 teachers and offers seven semester hours of graduate or under-graduate credit.

Applicants should be teaching at least one biology course currently, and should have at least three years' secondary level teaching experience. Teachers will be permitted to bring their families. Those who choose to live on campus will be housed in Muse Hall. Stipends will be awarded for the course period and participants will receive dependency and travel allowances.

The institute is financed by a \$47,795 grant from the National Science Foundation and will emphasize teaching methods for basic ecology concepts in high school classes.

SUMMER SCIENCE INSTITUTE

Randolph-Macon Woman's College, Lynchburg, Virginia, has received a grant of \$75,828 from the National Science Foundation to sponsor its thirteenth Summer Science Institute for high school teachers. The 1971 institute will be the second session of a three-year program that may lead to a masters degree in science teaching. The graduate degree program, initiated last year, was based on the institutes in science and mathematics which have been held at R-MWC in 12 of the last 13 years. The courses were designed at the graduate level, and twenty-four credits plus a thesis for six credits are the requirement for the masters degree.

Dr. Helen L. Whidden, professor of chemistry and director of the institute, describes the institute as a multiple-field program with courses in biology, chemistry, mathematics, and physics. It will run from June 23 to August 17, 1971, and is open to both men and women teachers of secondary school science subjects and mathematics. Entrance at any stage

in the sequence is possible.

MOUNTAIN LAKE SUMMER SESSION

The University of Virginia has announced the program of graduate biology courses to be offered this summer at the Mountain Lake Biological Station in southwestern Virginia. They are as follows:

First Term—June 16 through July 21

Animal Behavior: Dr. Robert L. Jeanne, University of Virginia

Experimental Morphogenesis: Dr. James Dent, University of Virginia

Plant Ecology: Dr. Gary L. Miller, Eisenhower College

Ornithology: Dr. David W. Johnston, University of Florida

Second Term—July 23 through August 26 Comparative Endocrinology: Dr. B. E. Frye, University of Michigan Entomology: Dr. George W. Byers, University of Kansas

Plant Biosystematics: Dr. C. Ritchie Bell, University of North Carolina at Chapel Hill

Principles of Parasitism: Dr. G. B. Solomon, The School of Veterinary Medicine, University of Pennsylvania

A limited number of National Science Foundation scholarships are available for research and study: (1) Pre-doctorate for supervised research, stipend \$500; and (2) Post-graduate for training in field biology, stipend \$400. Preference is given for studies concerned with the biota of the region. Application blanks for these awards may be secured from the Director, Mountain Lake Biological Station, Department of Biology, University of Virginia, Charlottesville, Virginia 22903 and must be submitted before May 1, 1971.

WATT A DEAN

Dr. William J. Watt will become dean of the College at Washington and Lee University July 1, 1971, succeeding Dr. William Webb Pusey III, who will return to full-time teaching as head of the department and professor of German after 11 years as head of the university's arts and sciences division. Dr. Watt, 45, is currently associate dean of the College and professor of chemistry at Washington and Lee and serves as chairman of the faculty's Executive Committee. He is a member of the Virginia Academy of Science.

Dr. Watt, a member of the faculty at Washington and Lee since 1955, earned his B.S. degree from the University of Illinois in 1949, his master's degree from Cornell University in 1951, and the Ph.D. degree in inorganic chemistry from Cornell in 1956.

He was named assistant dean of the arts and sciences division at Washington and Lee in 1966, and became associate dean two years later.

The dean of the College is considered the second-ranking academic officer in the university, and in addition to customary administrative duties he acts in the president's behalf during his absence or illness. The dean also serves as an *ex officio* member of many principal faculty committees.

The College includes 19 academic departments, which offer a total of 539 courses in 28 separate fields. This year, 1,060 students are enrolled in the College, almost 80 per cent of the university's undergraduate total. Its full-time faculty numbers 105.

SCIENCE MUSEUM OF VIRGINIA

Governor Linwood A. Holton has named seven of nine trustees of the planned Science Museum of Virginia. These include Dr. Roscoe D. Hughes, a past president of the Virginia Academy of Science, and a member of the Science Museum Study Commission and Dr. Avery Catlin of the University of Virginia, a member of the Virginia Academy of Science Council, representing the Materials Science Section. Dr. Hughes currently serves the Academy as Chairman of its Committee on Conservation and Natural Resources. Others appointed by Governor

Holton are Mrs. J. T. Bird of Salem, Mrs. William A. Stuart of Rosedale, Harold Soldinger of Portsmouth, William J. Vaughan of Virginia Beach and Mrs. William T. Reed, Jr., of Manakin-Sabot.

The General Assembly last year appropriated \$66,500 in planning money for the proposed museum with a portion of the money to be used in hiring an executive director. A site for the proposed museum has not yet been selected.

COMMITTEE ON ENVIRONMENT

Commissioner Maurice B. Rowe has announced the establishment of an environmental planning committee under the Virginia Department of Agriculture and Commerce which will study and make recommendations on environmental problems within the state. The committee, organized in November, is studying such subjects as pesticides and the disposal of animal and industrial wastes. It will collaborate with environmental specialists at Virginia Polytechnic Institute and State University in Blacksburg and the Governor's Council on Environment.

The five-man committee includes chairman J. W. Midyette, Jr., director of technical services in the agriculture department; J. E. Norment, Division of Administration; Dr. A. L. Stafford, Division of Animal Health and Dairies; G. J. Stoneman, Division of Markets, and C. K. Spruill, Jr., Division of Regulatory Services.

CONSERVATION AND NATURAL RESOURCES

Dr. Roscoe D. Hughes, Chairman of the Committee on Conservation and Natural Resources of the Virginia Academy of Science, has set up a temporary office at 6300 River Road, Richmond, Virginia 23229, thanks to the generosity of Dr. Sam Gillespie, Director of the Virginia Institute for Scientific Research. In trying to find ways and means of improving our environment, one of the things being considered by the Committee is the possible establishment of an Institute of Human Ecology which would be non-partisan and multi-disciplinary. Your expressions of interest and comments are solicited by the Committee.

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The Editor and the Business Manager of the *Journal* urge members of the Virginia Academy of Science and other readers to support our advertisers whenever possible. Mention that you saw their ads in the *Virginia Journal of Science*!

Additional advertising from industrial and business firms is desirable. Your personal contacts may be especially helpful in assisting the *Journal* to obtain new advertising, and we encourage your efforts in this regard. All inquiries should be directed to Dr. Charles O'Rear, Business Manager, 1 North Fourteenth Street, Richmond, Virginia 23219. We would welcome a member of the Academy to work with the business manager on advertising. Who will volunteer?

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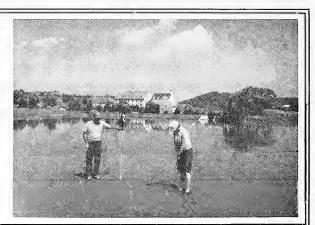
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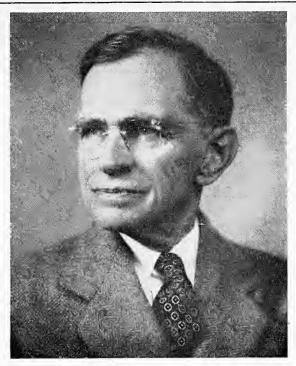
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The front cover is by Douglas C. Hensley.



William Allison Kepner 1875=1971

William Allison Kepner, eleventh president of the Virginia Academy of Science and Professor Emeritus of Biology, University of Virginia, died on March 24, 1971 at Charlotte, North Carolina.

Professor Kepner was born July 9, 1875 at Mount Alto, Franklin County, Pennsylvania.

His family were early settlers in Lancaster County, Pennsylvania and in the Valley of Virginia. Following graduation from Gettysburg Academy in 1894 he entered Franklin and Marshall College where he earned the A.B. degree in 1898 and the A.M. in 1900. In 1926 his alma mater awarded him the D.Sc. degree. Following a summer of graduate study at the University of Gottingen in 1903, he was named a fellow at Princeton for the session of 1903-1904. His Ph.D., earned in 1908, was the second given in biology at the University of Virginia.

After two years of teaching in the Philippine Islands he was named an instructor in biology at the University of Virginia in 1904, adjunct professor in 1908, associate professor in 1912 and professor of biology in 1917. The last position he held until his retirement from active teaching

in 1946.

His many years of association with the University of Virginia left his mark not only on the faculty but on the hundreds of students that came in contact with him. No student who took his course in Biology 1-2 failed to recognize him as a truly dynamic person and an inspiring teacher. With chalk drawings and clay models he illustrated his lectures so that even the dullest student in the class could not fail to realize the organization of the bit of protoplasm under study. He held the attention of the class until the last stroke of the Chapel bell. At the end of the final lecture of the session he was always awarded a resounding stamping of the feet—a mark of approval, appreciation and affection.

Over three hundred students were fortunate to have the privilege of taking his advanced course in Invertebrate Zoology. Here he worked in close and personal contact with them, calling their attention to unique features of the minute organisms being studied under the microscope. Dr. Kepner was a superb microscopist and skilled maker of slides. While some of his students may have surpassed him in scientific acclaim and achievement none have ever equalled him as a teacher. He himself wrote "I am grateful to the many students who have tolerated me, and who, in some

cases have held me in mind as a friend and teacher."

Dr. Kepner was a member of many learned and scientific societies and organizations including the American Association for the Advancement of Science, the American Society of Zoologists, Phi Beta Kappa, The Society of the Sigma Xi and The Raven Society. In 1958 he was the recipient of the Algernon Sydney Sullivan Award. He was most active in the formation of the Virginia Academy of Science, and served as its president in 1933–1934. With his passing we have lost a truly great teacher, a beloved personality and a distinguished gentleman.

Dr. Kepner leaves three children, Mrs. Edwin C. McClintock, Mrs. Alfred J. Short and William

Berrien Hooper Kepner.

Miles F. Johnson

Department of Biology General Academic Division Virginia Commonwealth University Richmond, Virginia 23220 Received[†] November 20, 1970

The Genera Carphephorus, Mikania and Kuhnia (Eupatorieae-Asteraceae) in Virginia

Abstract—The Eupatorieae of the Asteraceae is represented by about nine genera in the Virginia flora. Of these, Liatris has been treated separately by the author; Mikania, Kuhnia and Carphephorus are included in this paper. The remaining genera (Eupatorium and closely allied genera) will be dealt with in separate treatments later.

A key to Liatris, Mikania, Kuhnia and Carphephorus is presented. Brief genus and species descriptions, ecological data, flowering and fruiting dates and distribution maps for each species are given. Known chromosome numbers

are included.

Introduction

This paper is the second in a series dealing with the floristics of the Virginia Eupatorieae (Asteraceae). Liatris is treated separately in the first paper of the series by Johnson (1); Carphephorus, Mikania and Kuhnia are considered in this paper. The remaining genera, Eupatorium and closely allied genera, will be dealt with later.

This study is based upon collections found in herbaria of the following institutions: College of William and Mary, Williamsburg; Longwood College, Farm-ville; Lynchburg College, Lynchburg; Old Dominion University, Norfolk; Virginia Commonwealth University, Richmond; Virginia Polytechnic Institute and State University, Blacksburg; the United States National Herbarium, Washington, D. C.; the Gray Herbarium, Cambridge, Massachusetts, and the New York Botanical Garden, Bronx, New York. I gratefully acknowledge the help and assistance given by the curator and/or director of the herbarium at each of the institutions for allowing me to study the collections. Travel funds were provided by the Virginia Academy of Science and Virginia Commonwealth University. One hundred thirty-one specimens have been examined and Mikania scandens and Kuhnia eupatorioides have been observed in the field in 1969 and 1970.

Dots on maps (Fig. 1, 2A, 2B) indicate exact locations; closed triangles indicate a collection from that county without specific location data. Open circles are used to indicate collections cited in literature though not all specimens have seen personally.

† Revised February 24, 1971.

Nomenclature and descriptions generally follow those of Radford, Ahles and Bell (2), Fernald (3), and Gleason and Cronquist (4).

Taxonomic Treatment

The Eupatorieae, as a tribe, is delimited by the following characteristics: perennials with watery sap; flowers tubular, perfect, purple, rose, white or whitish, never yellow; style branches clavate and stigmatic near the base; anthers blunt at the base; leaves alternate, opposite or whorled; pappus, in ours, of capillary bristles.

Key to Genera

Receptacle chaffy, flowers rose to white; leaves opposite; extreme SE Virginia 4. Carphephorus. Receptacle not chaffy; flowers cream colored; leaves alternate; widespread in Virginia

.....2. Kuhnia.

1. Liatris Schreber. Blazing Star; Gay Feathers.

Perennial herbs with erect stems from a globose naked corm. Leaves alternate, linear to narrowly lanceolate, oblanceolate to obovate, cauline and basal. Heads cylindrical or hemispheric, in spikes or racemose, the heads blooming from top to bottom of the rachis. Involucral bracts imbricate in several series. Flowers in shades of lavender, rarely white. Achenes tapered from base to apex, dark in color. Pappus capillary, barbellate.

Five species in Virginia's flora were treated in a

separate paper (1).

2. Mikania Willd. Climbing Hempweed.

Perennial twining vine, to 3 m or more long (2). Leaves opposite, cordate. Flowers pinkish to white, 4 per head. Involucral bracts four.

Mikania is a large tropical genus with 152 species reported from Brazil (5). It is represented in Virginia by a single appairs

ginia by a single species.

1. Mikania scandens (L.) Willd. Climbing Hempweed.

Leaves opposite, triangular to cordate, (4.0-) 5.0–9.0 (-10.5) cm long, 3.0–8.0 cm wide, apex long acuminate, borne on petioles 2.0–5.0 (-6.0) cm long; heads in corymbs; involucres 4.0–6.0 mm long; achenes 5-ribbed, 2.0 mm long, resinous-glandular; pappus 3.0–4.0 mm long; corollas usually lilac to purplish, rarely white. 2n = 38 (6); 2n = 36 (7); n = 19 (2); n = 18 (8); n = 19 (9, 10).

Most common in moist thickets, along streams, in swamps, on lake shores, in both brackish and fresh water marshes, less common in dryer habitats, generally throughout the Piedmont and Coastal Plain, but rarely west of the Blue Ridge (Fig. 1). It is reported as frequent from the Potomac River to the Rapidan River by Allard and Leonard (11) and frequent in Fauquier County (12). Massey (2) reports *M. scandens* from Giles, Craig, Pulaski, Montgomery, Chesterfield and Prince William counties though the specimens have not been seen by this author. The species range extends from southern Ontario, New York and Maine on the north along the coast to Texas (3) and into Mexico and Central America, inland to Michigan and Missouri (4) and pantropically.

In Virginia, M. scandens is in flower from (late July-) August to late September; in fruit from mid-

August to early October.

Mikania scandens is unique as it is the only twining member of the Asteraceae in the state.

Pubescent plants with fleshy leaves and milk white flowers have been segregated as var. pubescens (Muhl.) T. & G. (3). These characters are not always evident in dried material as noted on Fernald and Long 4229 (VPI). The label states "leaves very fleshy" but these leaves do not appear appreciably different from other specimens seen. Continued study will be required to determine the status of this variety in Virginia.

3. Kuhnia L. False Boneset.

Resin dotted perennials with alternate leaves. Flowers cream-colored, borne in paniculate-corymbose heads. Involucral bracts narrow, striatenerved. Achenes 10-ribbed or angled. Pappus of plumose bristles.

The genus, consisting of about 6 species native to the United States and Mexico, is represented in our flora by the following single species.

1. Kulmia eupatorioides L. False Boneset.

Perennial herbs to 12 dcm tall, from a large woody caudex; root a taproot; leaves alternate, elliptic to lanceolate, the basal ones (3.0-) 6.0–8.5 cm long, (1.0-) 1.4–1.8 (-4.3) cm wide, irregularly to short petiolate; involucre cylindrical to campanulate, 6.0–8.0 mm long; achenes tapered apically, 4.0–5.0 mm long, 10-ribbed or angled, pubescent; pappus plumose, tawny, rarely white, 4.0–5.0 (-6.0) mm long, 2n = 18 (13).

Associated with shale in the mountains, less common on roadbanks, in dry oak-hickory woods, in dry fields and on limestone barrens in the Piedmont (Fig. 2A), closely paralleling the Ridge and Valley Province of Hoffman (14), and rare on the Coastal Plain. Thorne and Cooperrider (15) and Cooperrider and Thorne (16) list *K. eupatorioides* on rocky calcareous bluffs in Giles County, and Freer (17) lists this

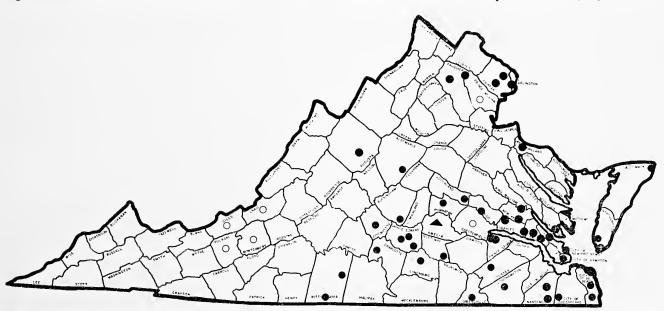


Fig. 1—Distribution of *Mikania scandens* in Virginia, Closed dots indicate exact locations. Closed triangles indicate a collection from that county without specific location data. Open circles indicate collections cited in literature though the specimens have not been seen personally.

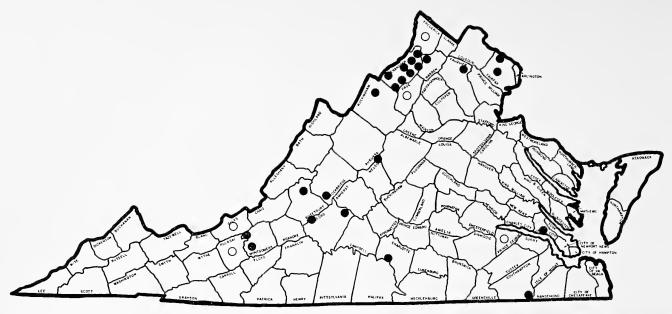


Fig. 2A—Distribution of Kulmia eupatorioides in Virginia. Closed dots indicate exact locations; open circles indicate collections cited in literature though the specimens have not been seen personally.

species from a dry roadside bank in Bedford County. Allard and Leonard (12) describe *Kuhnia* as infrequent in the Hopewell Gap area of Fauquier County. Massey (2) reports this species from Prince George, Frederick, Page, Giles and Pulaski counties though these specimens have not been examined by the author. The species range extends from New Jersey, Pennsylvania, Ohio and Indiana on the north to the Gulf on the south and Illinois and Missouri on the west (3). Variety *corymbulosa* T. & G. extends north into Wisconsin (18) and Minnesota and west to Montana.

This species is generally in flower from (late July-) to August to late September and in fruit from (late July-) August to early October. One specimen was seen which was collected on June 24 with

buds and few open inflorescences.

Shinners (19) recognized four geographic varieties, of which only the typical variety characterized by minute pubescence in the inflorescences occurs in our flora.

Kuhnia eupatorioides is distinguished from similar species by the alternate leaves and by cream-colored flowers borne in corymbose-paniculate heads.

4. Carphephorus Cass.

Resembling *Liatris* but differing in possessing corymbose inflorescences, in having receptacle paleae near the margin and in lacking the bulbous subterranean stems. Name from the Greek, *carphe*, chaff, and *phoros*, bearing (3).

The genus consists of four species which are found from southeast Virginia to south Florida and to eastern Louisiana (20). The Virginia species are

distinguished as follows:

Key to Species

Bracts pubescent, the margins pectinate-ciliate; basal leaves generally small, oblanceolate, to 4

4a. Carphephorus tomentosus (Michx.) T. & G.

Perennial herbs 3.8-5.5 dm tall, generally spreading-hirsute; leaves oblanceolate, 3.5-13.0 cm long (including the petiole), 0.4-1.0 (-1.2) cm wide, crenate-dentate to subentire, the base cuneate, sessile progressively smaller and sessile toward the inflorescences; involucre campanulate, (0.7-) 0.9-1.2 cm long, the bracts acute and pubescent with pectinate-ciliate margins; achenes 3.0-4.0 mm long; pappus about 7.0 mm long. 2n = 20 (21); n = 10 (22).

This species occurs most commonly in pine and oak woods, in white sand and peaty pine barrens, less commonly in sphagnous bogs, in open sand and clayey soils in four southeast Virginia counties (Fig. 2B). This distribution is very similar to that of the following species, *C. bellidifolius*. The total

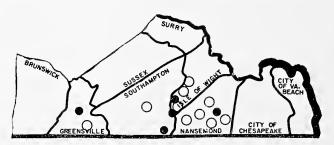


Fig. 2B—Distribution of Carpehphorus in Virginia. Open circles indicate distribution of Carphephorus tomentosus in Virginia; closed dots indicate distribution of Carphephorus bellidifolius in Virginia.

distribution extends from Florida to southeast Virginia on the Coastal Plain (3).

In Virginia, *C. tomentosus* is in flower from mid-July to mid-October; in fruit from late August though October.

Fernald (23) proposed the name Carphephorus tomentosus (Michx.) T. & G. var. Walteri (Ell.) Fernald to include those plants which possess glabrous lower leaves but otherwise have the characters of C. tomentosus. These plants are distinct and thus are recognized in the flora. However, more study is required to determine the exact relationship of var. walteri.

4b. Carphephorus bellidifolius (Michx.) T. & G.

Perennial herbs 3.0–7.5 dm tall; generally glabrous to nearly so on the stem and puberulent on the peduncles; lower leaves oblanceolate to spatulate, 12.0-15.0 cm long (including the petioles), 1.5-3.0 cm wide, the upper progressively smaller; involucre campanulate to hemispheric, 1.0-1.2 cm high, the bracts apically rounded, glabrous, the margin ciliate to erose; achenes 5.0-6.0 mm long, pappus 7.0-9.0 mm long, 2n = 20 (21).

Endemic to the southeastern United States, C. bellidifolius occurs in white sand pine barrens, dry sandy oak woods and dry sand in four southeast Virginia counties (Fig. 2B). This distribution and that of C. tomentosus closely parallel the sand and clay soil parent material of the Flat Woods of the Coastal Plain Province as mapped by Wingo (24). The total range extends from southeastern Virginia to Georgia on the Coastal Plain (2) and to

Florida (3, 4).

Carephephorus bellidifolius is generally in bloom in September; in fruit in October. One specimen, in

flower, was collected in mid-July.

The two species in this genus in Virginia, though somewhat similar in appearance, are readily distinguished by the pubescent bracts of *C. tomentosus* vs. glabrous bracts in *C. bellidifolius*, and by the wider leaves and more numerous inflorescences in *C. bellidifolius*. See also the papers by James (20) and Hebert (25).

Another member of the tribe, Sclerolepis uniflora (Walt.) BSP., a smooth perennial with usually single stems, small linear whorled leaves and a single terminal inflorescence, is to be expected in Virginia. The plant has been collected in Maryland (specimen at US) and from Northampton County, N. C., (2)

which borders on Virginia from bogs, ditches and low savannahs. Knowlton (26) describes *S. uniflora* as characteristic of pine barrens of the Middle and South Atlantic States which obviously includes Virginia. Nevertheless, manuals for our region (3, 4) describe the distribution extending on the Coastal Plain from Florida to New Hampshire, but exclude Virginia. Why docs *S. uniflora* not occur in Virginia?

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Estimates of Phenotypic, Genetic and Environmental Parameters in a Herd of Angus Cows^{1,2}

Abstract-Preweaning performance records on 2,604 calves out of 769 cows were used to calculate heritability and phenotypic, genetic and environmental correlations for preweaning average daily gain (ADG) and weanling grade in a herd of Angus cattle. Heritability estimates of calving interval were also calculated from 3,989 records from the same 769 cows.

Paternal half sib analyses of variance and covariance were used to obtain the heritability and correlation estimates. Heritability estimates of $0.57 \pm .09$, $0.31 \pm .02$ and $0.03 \pm .20$ were obtained for preweaning ADG, weanling grade and calving interval, respectively. Estimates of $0.24 \pm .02$, $0.16 \pm .08$ and 0.37 were obtained for phenotypic, genetic and environmental correlations, respectively, between preweaning ADG and weanling grade.

Introduction

The productivity of a beef cow is measured by her ability to wean a heavy calf of desirable conformation each year. To be most effective in selecting herd replacements, the breeder must know how heritable each trait under selection is and how the several traits are related to each other. Since all traits are both hereditary and environmental, it is important to know the relative influence that each has on a given economic trait under local environmental conditions. If the expression of the trait in question is controlled largely by environmental conditions such as feed, weather, etc., then little will be gained from selecting for that trait in the breeding stock. On the other hand, if the expression of the trait is little affected by environmental conditions it is said to be highly hereditary and progress can be made in the breeding stock by selecting animals that express the desired trait to a high degree. Most traits of economic importance in cattle are thought to be somewhere in between these two extremes.

Because of the pleiotropic effect of genes or because genes that affect different traits are located on the same chromosome, there is sometimes a correlation between two or more traits of economic importance. Sometimes this correlation is positive and sometimes it is negative. The breeder needs to know these relationships in order to plan the most efficient selection program. For example, there is a high positive correlation between growth rate and feed efficiency in beef cattle. By selecting for growth rate alone the breeder can make about 80% as much progress in improving the feed efficiency of his animals as if he went to the great expense of obtaining individual feed records and using them as a basis for his selection. Therefore, in order to predict effectiveness of selection for traits of economic importance in beef cattle, it is necessary to have estimates of phenotypic, genetic and environmental parameters of the traits involved.

The purpose of this study was to obtain estimates of heritability of preweaning average daily gain (ADG), weanling grade and calving interval, and phenotypic, genetic and environmental correlations between preweaning ADG and weanling grade in a large herd of Angus cattle in Southwest Virginia.

Materials and Methods

The Data. Data obtained from a purebred herd of Angus cows, increasing in size from 250 productive cows in 1955 to 350 cows in 1965, were used for the calf performance portion of this study. Records were collected by the Virginia Beef Cattle Improvement Association (BCIA) over the years 1955 through 1965. Usable performance records were available on 2,604 calves from 769 cows by 43 sires. The number of offspring per sire varied from 11 to 196, with an average of 60.5 calves. Sires were used in the herd for an average of 3.4 years with a range from 1 to 7 years. Cows were bred to calve either in the fall or in the spring, with the peak months being October and March. Some calves were born in each month but the number was quite small during June, July and August. Calves varied in age at time of weighing and grading from 120 to 299 days with an average age of 192 days and a standard deviation of 38 days. Cows varied from 2 to 19 years of age at time of calving. For the analysis they were grouped by age as 2, 3, 4, 5, 6–7, 8–11 and over 11 years.

Weights were taken by a BCIA Fieldman and

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Division and the Chief of the Been Cattle Research.
USDA.

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grades were assigned by a member of the Virginia Livestock Grading Service. The grading system used was that described by Marlowe, Kincaid and Litton (1). Weanling grades ranged from 6 to 16 with an average of 11.6 and a standard deviation of 1.5. The average weight of the calves was 366 lb., with a standard deviation of 68 pounds. The preweaning average daily gain (ADG) and weanling grade data were adjusted for age, sex and month of birth of calf and age of dam as described by Marlowe, Mast and Schalles (2).

Parameter Estimates. Estimates of heritability, and genetic, environmental and phenotypic correlations were obtained for these traits from paternal half-sib analyses of variance and covariance on a within-year and within-age-of-dam basis. There were 11 years and 7 age-of-dam groups. Equations used for heritability (h^2), genetic correlation ($r_{g_xg_y}$), environmental correlation ($r_{e_xe_y}$) and phenotypic correlation ($r_{p_xp_y}$) are as follows:

$$\begin{split} h^2 &= \frac{4\sigma^2 s}{\sigma^2 s + \sigma^2 w} \\ r_{g_{xgy}} &= \frac{\sigma s_{(xy)}}{\sqrt{\sigma^2 s_{(x)} \sigma^2 s_{(y)}}} \\ r_{e_{x}e_{y}} &= \frac{\sigma w_{(xy)} - 3\sigma s_{(xy)}}{\sqrt{\sigma^2 w_{(x)} - 3\sigma^2 s_{(x)}} \sqrt{\sigma^2 w_{(y)} - 3\sigma^2 s_{(y)}}} \\ r_{p_{x}p_{y}} &= \frac{\sigma w_{(xy)} + \sigma s_{(xy)}}{\sqrt{\sigma^2 w_{(x)} + \sigma^2 s_{(x)}} \sqrt{\sigma^2 w_{(y)} + \sigma^2 s_{(y)}}} \end{split}$$

where $\sigma^{2}s$ is the sire component of variance, $\sigma^{2}w$ is the within component of variance and the subscripts (x and y) designate the traits involved. $\sigma w_{(x,y)}$ and $\sigma s_{(x,y)}$ are covariance among traits X and Y on a within- and among-sire basis, respectively. Standard errors for the heritability estimates were calculated according to Dickerson (3).

The heritability estimate for average calving interval was also obtained from a paternal half-sib analysis. An approximate standard error for the genetic correlation was obtained according to the equation given by Falconer (4). The standard error for the phenotypic correlation $(\mathbf{r}_{\mathbf{p}_{x}\mathbf{p}y})$ was obtained by the equation: s.e. $\mathbf{r}_{\mathbf{p}_{x}\mathbf{p}y} = [1/N - 3(\Sigma \mathbf{n}_{i})]$, where \mathbf{n}_{i} is the number of age-of-dam groups represented in year i and N is the total number of observations as described by Marlowe and Vogt (5).

Results and Discussion

Least squares analyses of variance showed that both age of dam and year effects on average daily gain (ADG), weanling grade and calving internal were highly significant. Therefore, these effects were included in the statistical model for estimating heritabilities and phenotypic, environmental and genetic correlations. Least squares means and constant estimates are shown in Table I. The overall regression of ADG on years was negative (-.07) whereas the regression of grade on years was positive (0.13).

Month and year of birth of calf and age of dam all had a significant effect on length of calving inter-

TABLE I

Least Squares Means (LSM) and Deviation from LSM for Average Daily Gain (ADG) and Weanling Grade

Factor	Observations	ADG	Grade
Least Squares Mean	2604	1.59	11.5
Age of dam			
2 yr. olds	290	12	0.03
3 yr. olds	335	06	0.12
4 yr. olds	350	0.02	0.13
5 yr. olds	311	0.05	0.13
6–7 yr. olds	508	0.06	0.07
8–11 yr. olds	600	0.07	0.00
12 yr. and older	210	02	48
Years		b =07	b = 0.13
1955	150	0.03	51
1956	212	0.08	35
1957	239	0.03	53
1958	204	03	18
1959	190	05	61
1960	194	03	23
1961	232	0.01	0.36
1962	270	0.03	0.27
1963	312	03	0.34
1964	299	0.00	0.82
1965	302	04	0.62

val. For each year increase in age of cow the calving interval increased by 1.5 days. Cows calving in May and August had a calving interval of 419 days and those calving in June and July had an interval of 445 days. The mean was 398 days. The shortest calving interval occurred among cows that calved in January through March which is the most prevalent calving season in Virginia. These cows would have been bred while on spring pasture and gaining in weight and condition. The year to year fluctuations were probably the result of good or poor grazing conditions the previous year.

Heritability Estimates. The heritability estimates obtained were $0.57 \pm .09$ for preweaning ADG, $0.31 \pm .02$ for weanling grade and $0.03 \pm .20$ for calving interval. The heritability estimate for preweaning ADG is somewhat higher than most estimates reported in the literature. Brinks et al. (6) reported an estimate of $0.40 \pm .06$ but most estimates have been nearer 0.30, especially when a large number of observations were used. Marlowe and Vogt (5) obtained estimates of $0.49 \pm .10$ for Angus bull calves, $0.43 \pm .06$ for steer calves, $0.31 \pm .06$ for heifer calves and $0.38 \pm .03$ for combined sexes. Their estimates were based on 12,134 offspring of 1,453 sires in 100 herds.

The heritability estimate of $0.31 \pm .02$ for weanling grade is in line with most estimates reported in the literature. Petty (7) summarized the heritability estimates found in the literature, and calculated an overall weighted average estimate of 0.292 for weanling grade. Marlowe and Vogt (5) reported an estimate of $0.36 \pm .04$ for the combined sexes of Angus cattle and $0.33 \pm .04$ for Hereford cattle.

The heritability estimate of $0.03 \pm .20$ for calving interval is in good agreement with that reported by Legates (8) for dairy cows of 0.026, but slightly

lower than those reported by Lindley et al. (9) for beef cattle which ranged from 0.07 to 0.17, de-

pending on the method of calculation.

Phenotypic, Environmental and Genetic Correlations. Correlations were obtained between preweaning ADG and weanling grade from paternal half-sib analyses of variance and covariance. Estimates obtained were $0.24 \pm .02$ for phenotypic, $0.16 \pm .08$ for genetic and 0.37 for environmental correlations. All correlations are slightly lower than most estimates reported previously. However, the phenotypic and genetic correlations do not deviate far from those reported by Marlowe and Vogt (5), whose calves were graded by the same graders.

Conclusions

The parameter estimates obtained in this study add to the general knowledge of the importance of genetic and environmental influences on three of the most important economic traits in beef production, namely, regularity of reproduction, ability to gain rapidly from birth to weaning and to produce an

animal of desirable conformation.

The magnitude of the heritability estimates for preweaning ADG and weanling grade indicates that selection for these traits would result in genetic improvement at a modest rate. On the other hand, the low estimate for calving interval suggests that a breeder would be wasting his time and efforts in selecting for genetic improvement to shorten the calving interval. Improvements in this trait must come about through better management practices, such as breeding during the best time of the year, improving feed supply, using bulls of known high fertility and others.

The positive correlation eoefficients between

ADG and grade, although low, indicate that by selecting for one of these traits some progress will be made in the other trait also. Even more important is the fact that there is no antagonism between these two economically important traits and that genetic improvement can be made in both traits simultaneously through selection.

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Some Predators of Polyps of *Chrysaora quinquecirrha* (Scyphozoa, Semaeostomeae) in the Chesapeake Bay*

Abstract—Some invertebrate predators of polyps of Chrysaora quinquecirrha were identified. They included Caprella equilibra, Callipallene brevirostris, Neopanope texana sayi, Pagurus longicarpus, Libinia dubia, and Cratena pilata. Only C. pilata showed a preference over other possible prey organisms.

Introduction

The Chesapeake Bay is plagued each year by the Scyphozoan Chrysaora quinquecirrha. The abundant medusoid form of this animal is a nuisance to swimmers and fishermen, and causes economic loss to businesses which profit from visitors to our seashores. On occasions it has clogged intake screens on power plants which use estuarine waters for cooling. At times it also causes trouble in the cooling systems of vessels. The ecology of C. quinquecirrha has been studied by various workers (1–4, and others). Further study is needed to determine predators which may control populations in the estuary.

Known predators of the free floating medusa and ephyra forms include the harvest fish *Peprilus ale-pidotus*, the anemone *Diadumene leucolena*, the spider crab, *Libinia dubia* and the barnacle *Balanus eburneus* (1, 2, 5, 6). The sessile polyp stage might be expected to be subject to predation by many species. One organism which has been extensively studied is the nudibranch *Cratena pilata*, an organism capable of selectively ingesting polyps at a rapid rate (1, 7). The present research was directed toward determining the possible role of other common benthic invertebrates as predators on polyps.

Materials and Methods

Epibenthic species from several taxa were tested as possible predators (Table I). The animals examined had habitats similar to those of the polyp of *C. quinquecirrha*. Work on this project was completed during the months of June and July 1969.

In an initial evaluation of a species as a predator, five or more individuals were placed in a large fingerbowl containing a known number of polyps.

After 24 to 72 hours, the remaining polyps were counted. Animals tested were considered possible predators if more than 25% of the polyps were destroyed during the test. Controls consisted of a known number of polyps in a fingerbowl. The mortality in the control bowls was compared to the mortality under experimental conditions.

Animals designated as possible predators were further tested to determine whether scyphopolyps were the preferred prey. Specimens were placed in a 12-inch fingerbowl containing polyps, and the behavior of the organisms was observed through a dissecting microscope. Controls were maintained in separate bowls. Results were considered positive when the suspected predator was seen ingesting a *C. quinquecirrha* polyp. Tests were repeated to confirm initial observations.

Polyps used in the study were attached to freshly collected oyster shells bearing other epibenthic organisms (hydroids, sponges, bryozoans). The shell

TABLE I
Summary of Animals Screened as Possible Predators of Polyps of
Chrysaora Quinquecirrha Showing Positive (+)
and Negative (-) Predation

Species	Length range mm	Results	
Gammarus sp.	4	_	
Caprella equilibra	5–8	+	
Corophium sp.	5-10	_	
Cyatlnıra carinata	10-15	_	
Palaemonetes sp.	30-40	_	
Libinia dubia	30-40	+	
Neopanope texana sayi	25-40	+	
Pagurns longicarpus	15-20	+	
Nereis succinea	25-45	_	
Hydroides hexagona	15-20	_	
Glycera dibranchiata	40-50	_	
Nassarins sp.	15-20	-	
Urosalpinx cinerea	10–15	_	
Cratena pilata	2-5	+	
Callipallene brevirostris	1-2	+	
Stylochus ellipticus	2-4		
Coronadena mntabilis	2-4	_	
Opsanus tau	40-50		
Gobiesox strumosus	40-50	_	

^{*}Contribution No. 363 from the Virginia Institute of Marine Science. Supported in part by Public Law 89-720-Jellyfish Act.

TABLE II

Details of Experiments on Six Predators of Polyps of Chrysaora Quinquecirrha

			Control			
Species	Experiment Number	Days	Number Polyps	Percent Mortality	Number Polyps	Percent Mortality
Caprella	1	2	8	87	42	5
equilibra	2	3	15	100	26	11
	3	2	50	80	26	0
Callipallene	1	3	46	100	26	11
brevirostris	2	1	4	100	26	0
Neopanope	1	1	51	100	26	0
texana	2	4	125	92	40	0
Cratena pilata		1	4	100	26	0
Pagurus	1	1	16	100	42	5
longicarpus	2	3	100	91	26	11
Libinia	1	2	40	100	26	11
dubia	2	3	18	100	23	44

with its epifauna thus simulated a "natural environment," offering alternative prey to the attached scyphopolyps. Oyster shells with polyps were obtained from the York River and tributary creeks.

Results and Discussion

Six of the 19 species tested were regarded as predators (Table II). They were the caprellid amphipod Caprella equilibra, the pycnogonid Callipallene brevirostris, the mud crab Neopanope texana sayi, the hermit crab Pagurus longicarpus, the spider crab Libinia dubia, the nudibranch Cratena pilata. Mortality among test polyps ranged from 80 to 100% in tests lasting from one to four days. Each predator is discussed below.

Caprella equilibra. This amphipod moved over the oyster shell in an erratic manner. Both C. quinquecirrha and hydroid polyps were readily ingested. In feeding, the amphipod did not always use its large gnathopods.

Callipallene brevirostris. On contact with a polyp, C. brevirostris quickly grasped its prey with the chelifores and mouth appendages. Polyps were ingested by being sucked into the extended proboscis.

Neopanope texana sayi and Pagurus longicarpus. These decapods fed in a similar manner, crawling over the oyster shell and ingesting bryozoans, hydroids, and scyphopolyps. Polyps or other prey were grasped with the chelipeds, pushed to the mouth, and rapidly ingested. Both species were voracious predators in the laboratory; within 20 seconds each had devoured about 10 C. quinquecirrha polyps. Only one species of mud crab, N. texana sayi was studied, although other species of Xanthidae such as Eurypanopeus depressus or Panopeus herbsti may also be predators.

Libinia dubia. This species was reported to be a predator of the medusae of Aurelia aurita (6). The spider crab was also found to prey on the medusae of C. quinquecirrha. Such predation was frequently observed both in the field and in the laboratory. L. dubia feeds on scyphopolyps in the same manner as N. texana sayi and P. longicarpus. Feeding is in a non-selective fashion; other organisms (i.e., hydroids, bryozoans) are seized with the chelae and rapidly ingested.

Cratena pilata. This nudibranch, as indicated by Cargo and Schultz (1), and Vogel (7), appears to be the only predator that shows a feeding preference for scyphopolyps. C. pilata by-passes other food items and appears to search for C. quinquecirrha polyps; other materials, however, are ingested as well. No nematocyst reaction, except for a small twitch of the sensory rhinophores, was observed when the nudibranch made contact with polyps. C. pilata ingested polyps as quickly as it located them.

Five of the polyps predators identified in the present study are omnivorous in their feeding habits. These are *C. equilibra*, *C. brivirostris*, *N. texana sayi*, *P. longicarpus*, and *L. dubia*. All of the above possess a chitinous exoskeleton which provides protection from the nematocysts of the *C. quinquecirrha* polyps. The nudibranch *C. pilata*, a selective predator of scyphopolyps, has no exoskeleton, but is apparently not harmed by the nematocysts. It is suggested that these six invertebrate species, because of their abundance in the Chesapeake Bay, possess a high potential for destruction of *C. quinquecirrha* polyps. Further study of these predators and their feeding habits may suggest a natural method of controlling the jellyfish population in Chesapeake Bay.

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Studies on Azo Dye Stability as Related to Tumor Production in the Presence of Certain Benzimidazoles*

Abstract—2-Ethyl-5-methylbenzimidazole hastens the destruction of the azo dye 3'-methyl-4-dimethylaminoazobenzene in vitro but at a slow rate. Evidence is presented here indicating the inhibition of tumor formation by the azo dye in the presence of certain benzimidazole derivatives is probably not due to in vitro dye destruction. Diets in which the dye is more stable in the presence of benzimidazoles (containing partially hydrogenated vegetable oil or ascorbic acid) did not alter the effectiveness of the benzimidazoles in inhibiting azo dye carcinogenesis.

Introduction

We have reported previously that liver tumor induction by 3'-methyl-4-dimethylaminobenzene (3'me-DAB) could be inhibited by feeding 2,5-dimethylbenzimidazole or 2-ethyl-5-methylbenzimidazole (1). It has also been found that high levels of copper in the diet reduce the incidence of azo dye induced liver tumors, apparently, in part at least, by catalyzing destruction of the dye (2). The present studies were performed to measure azo dye destruction in the presence of benzimidazoles in the diet *in vitro* and to test some diets with varying degrees of dye lability on the induction of liver tumors in rats.

Methods

Procedures have been described in previous studies on the effects of benzimidazoles on carcinogenesis (1). Diets were prepared in two halves. The azo dye and the oil were kept separate from the benzimidazole so that the benzimidazole and the azo dye were not in contact until the two halves were mixed just prior to the studies on stability in vitro, or the beginning of the animal experiments. The complete diet had the following composition: 79% glucose monohydrate (cerelose), 4% Wesson salts, 12% casein, and 5% corn oil or other fat as indicated below. Vitamins were added so that each kg of complete diet contained 3 mg of thiamine HCl, 7.5 mg calcium pantothenate, 2.5 mg of pyridoxine, 2 mg of riboflavin, and 1 g of choline chloride. Tet-

raeyeline was added to diets at a level of 100 mg

For tumor experiments the animals (15 per group at start of experiments) were fed the dye-containing diet for 8 weeks followed by an additional 8 weeks on the dye-free diet. The animals were then sacrificed and presence of tumors observed grossly and microscopically. Analytical studies were performed after 3 weeks of feeding with five animals per group. The animals were sacrificed, livers removed and homogenized in water, and aliquots used for the appropriate analysis. Riboflavin concentration was determined by the fluorometric method of Connor and Straub (4) as modified by Andrews (5). Total azo dye concentration of the liver was determined by the method of Spain and Clayton (6).

Urine and feces from rats fed 3'me-DAB with and without 2-ethyl-5-methylbenzimidazole were analyzed for apparent azo dye (6) on days 3, 4, 8–11, and 30–32 to determine the effect of the benzimidazole upon excretion of the dye. The rats were pretrained to eat in a 2 hour period, and separate collection of urine and feces was made over a 22 hour period from individual animals placed in metabolism cages.

The azo dye concentration in food samples was determined at intervals by extracting a weighed aliquot three times with ether, decanting and filtering the ether each time, evaporating the combined ether extracts and making up to appropriate volume with 2 N HCl. The concentration of dye was determined spectrophotometrically using a known amount of azo dye in 2 N HCl as a standard.

per kg for the studies involving animal experimentation (3). The benzimidazoles were incorporated in the diet at 0.25% and the azo dye, 3'me-DAB, was at a level of 0.064%. For animal experimentation water was given ad libitum and food consumption was measured at intervals. Young adult Holtzman male rats weighing approximately 200 g at the start of the experiments were housed in wire-bottom stainless steel cages in groups of three to five. The animals were weighed and examined at weekly intervals.

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Dye stability in the presence of 2-ethyl-5-methylbenzimidazole. The dye (3'me-DAB) in freshly prepared diet containing 0.25% of the benzimidazole derivative was found to be stable for three days at room temperature and for 28 days in the cold (10 C). A diet prepared and placed in food cups (as fed to the rats) in the animal cage with animals showed no loss of azo dye under these conditions after 24 hours. Certain additions to the diet did affect the stability. The dye was stable for a month at room temperature upon the addition of ascorbic acid (1g/100g); α -tocopherol (500mg/100g) was somewhat less effective, and menadione (500mg/ 100g) had no effect upon stability. Studies with different fats indicated that the dye was more stable in the presence of 2-ethyl-5-methylbenzimidazole when the fat was partially hydrogenated vegetable oil (Primex), or hydrogenated coconut oil, or when no fat was included in the diet. Under these conditions the dye was stable for at least 28 days at room temperature.

The above results indicate that the dye was more stable in the presence of the benzimidazole than it was when high levels of copper were present in the diet (2), and it would appear that the effect of benzimidazoles in previous tumor studies (1) was not due to catalytic destruction of the dye *in vitro*.

Fecal and urinary excretion of azo dye. In two different studies with 2 rats fed the corn oil diet containing the dye, and 3 fed the same diet plus 2-ethyl-5-methylbenzimidazole, there was no consistent effect of the benzimidazole upon dye excretion. Individual variation between animals was quite great as was the variation from day to day for any individual rat. The similarity in exerction patterns between the two groups, however, would seem to indicate that the effect of the benzimidazole upon tumor induction was not to be accounted for by excretion differences.

Tumor studies. Since the type of fat in the diet did affect the stability of the azo dye in the presence of the benzimidazole derivative, experiments were performed comparing hydrogenated cottonseed oil versus corn oil with various benzimidazoles added at a level of 0.25% to the diets. Unsubstituted benzimidazole, 2,5-dimethylbenzimidazole, and 2-ethyl-5-methylbenzimidazole were used as liver tumor induction inhibitors. It was found (Table I) that without the addition of a benzimidazole to either the corn oil or the hydrogenated cottonseed oil containing diets, the tumor incidence was 100%. It was also found that unsubstituted benzimidazole at this level had little or no effect upon inhibiting tumor formation in this study; that is, 100% of the animals receiving this compound in the diet with hydrogenated cottonseed oil developed liver tumors. With the 2,5-dimethyl- or the 2-ethyl-5-methylbenzimidazole, no tumors developed with either fat. This would indicate that dye lability was not the protective action of the benzimidazoles as there was complete protection with the substituted benzimidazoles irrespective of the type of fat and little or no effect

Effect of Type of Fat in the Diet Upon Incidence of Tumors Resulting from Feeding .064% 3'me-DAB in the Presence of Various Benzimidazoles

Diet	tumors/ survivors	survivors with tumors
		070
Corn Oil	12/12	100
Primex	11/11	100
Corn Oil + .25% benzimidazole	14/14	100
Primex + .25% benzimidazole	10/14	71
Corn Oil + .25% 2,5-dimethylbenz- imidazole	0/15	0
Primex + .25% 2.5-dimethylbenz- imidazole	0/15	0
Corn Oil + 2-ethyl-5-methylbenz- imidazole	0/15	0
Primex + 2-ethyl-5-methylbenzimidazole	0/14	0

with the unsubstituted benzimidazole. This is comparable to previous results obtained with corn oil diets (1).

Since ascorbic acid offered protection against dye destruction in the presence of the benzimidazole, the effect of ascorbic acid, with and without .25% 2-ethyl-5-methylbenzimidazole in the diet, on the induction of liver tumors by 3'me-DAB was studied. Ascorbic acid was added at a level of 200 mg per kg of diet. The addition of ascorbic acid did not alter the incidence of tumors (100 vs 92%) and did not affect the inhibition of induction of tumors by 2-ethyl-5-methylbenzimidazole (7 vs 0%) (Table II).

Analytical studies. Analysis of livers of rats after 3 weeks on dicts to compare corn oil with partially hydrogenated vegetable oil (Primex) showed that the liver riboflavin was comparable between the two fats and that the more protective the benzimidazole, the higher the riboflavin concentration in the liver. The azo dye concentration of the liver decreased with the benzimidazoles in the diet and the more active the benzimidazole, the lower the concentration of the liver dye (Table III). The higher riboflavin (7) and lower azo dye (8) concentrations would be expected from the tumor studies.

Discussion

These studies indicate that certain benzimidazoles are effective in preventing the induction of liver

TABLE II

Effect of Ascorbic Acid and 2-Ethyl-5-methylbenzimidazole Upon Induction of Liver Tunors by 3'me-DAB

Diet	tumors/ survivors	survivors with tumors
		%
Control	10/10	100
Control + ascorbic acid	11/12	92
Control + 2-ethyl-5-methylbenzimidazole Control + ascorbic acid + 2-ethyl-5-	1/14	7
methylbenzimidazole	0/14	0

TABLE III

Effect of Different Benzimidazoles and Type of Dietary Fat Upon Riboflavin and Azo Dye Concentration in the Liver (µg/gm Fresh Weight) After 3 Weeks of Feeding a Diet Containing .064% 3'me-DAB (Ave. 5 rats/group)

Fat	Benzimidazole	Riboflavin	Azo Dye
		μg/gm	μg/gm
Corn Oil	NONE	17.8	32.7
Corn Oil	.25% benzimidazole	21.4	27.8
Corn Oil	.25% 2,5-dimethylbenz- imidazole	23.0	23.3
Corn Oil	.25% 2-ethyl-5-methylbenz- imidazole	25.9	18.7
Primex	NONE	21.4	35.0
Primex	.25% benzimidazole	19.4	26.2
Primex	.25% 2,5-dimethylbenz- imidazole	23.9	19.9
Primex	.25% 2-ethyl-5-methylbenz- imidazole	27.1	20.7

tumors by azo dyes in the rat but probably not because of dye destruction in vitro catalyzed by the benzimidazoles. It appears that the destruction of the dye that does occur is coupled with the oxidation of unsaturated fatty acids. This is similar to results that have been found with increased levels of copper in the diet (2) and azo dye destruction in the presence of linoleic acid (9).

Benzimidazoles will form metal chelates (10) which might possibly be effective catalysts in dye destruction. Metallo-organic complexes have been shown to be more effective in catalyzing certain oxidation-reduction reactions (iron salts vs. heme in catalase-like action [11]). The protective action of benzimidazoles toward liver tumor induction by azo dyes would appear more likely to be at a cellular level where such complexes might be involved. At present we have no indication how certain benzimidazoles function in preventing dye-induced liver tumors.

Summary

Inhibition of induction of liver tumors by azo dyes in the presence of certain benzimidazole deriv-

atives does not seem to be due to in vitro dye destruction. 2-Ethyl-5-methylbenzimidazole promoted in vitro dye destruction at a slow rate when the diet contained a fat high in polyunsaturated fatty acids (corn oil). The dye destruction was not measurable after 30 days at room temperature when the diet contained a partially hydrogenated vegetable oil or added ascorbic acid. Diets with these latter modifications and containing the liver carcinogen 3'-methyl-4-dimethylaminoazobenzene produced hepatomas in the absence but not in the presence of two different benzimidazoles, similar to the diet containing corn oil where the dye was less stable. Excretion of apparent azo dyc in the urine and feces was not altered by the addition of 2-ethyl-5-methylbenzimidazolc indicating that alteration in intestinal absorption of the dye was probably not a factor in the effectiveness of the benzimidazole.

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Some Comments on Ψ^2 (O) : The Non-relativistic Electron Probability Density at the Origin

Abstract—A reliable knowledge of $\Psi^2(O)$, the square of the Schrodinger wave function at the origin, is required for the interpretation of a variety of experimental results. In spite of its simplicity and inherent weaknesses, the Fermi-Segrè formula for $\Psi^2(O)$ has proved to be reasonably reliable as well as durable.

A review of the problem as well as a survey of the efforts made toward improving the accuracy of this quantity is the subject of the present article.

Introduction

Historically, the first problem to require a reliable knowledge of the quantity $\Psi^2(0)$ —the probability density of the optical s-electron at the nuclear origin, was in the determination of nuclear magnetic moments from measured values of the interval constant a, i.e. from magnetic hyperfine structure (hfs) data (1). (The interval constant a is defined by the equation $H_{\rm hfs} = a \, \langle I \cdot J \rangle$ where $H_{\rm hfs}$ is the hfs interaction energy, I = nuclear spin, J = total electronic angular momentum and where $\langle \ \rangle$, as usual, denotes an expectation value (1). For an $S_{1/2}$ electron a is sometimes referred to as the Fermi contact parameter.

The need for good electron wave functions at the origin is not limited to the problem of magnetic hfs. Other experiments in which $\Psi^2(O)$ plays a central role include: isotope shift (2), the Knight shift (3), and more recently, the isomer shift (4).

The Fermi-Segre Formula

The first derivation of $\Psi^2(O)$ was presented by Segrè and Fermi (5) in 1933. This result, remarkable in its simplicity, is given below, in Eqn. (1).

$$\Psi^{2}(O) = \frac{Z_{1}Z_{0}^{2}}{\pi a_{H}^{3}n_{0}^{3}} \left(1 - \frac{d\sigma}{dn}\right)$$
 (1)

(1) Where $a_{\rm H} = \text{Bohr radius}$

 Z_i = inner effective nuclear charge

 Z_0 = outer effective nuclear charge

 n_0 = effective quantum number

 σ = quantum defect

The Fermi-Segrè (F-S) formula is based on a JBWK approximation method in which the wave function for the s-electron at large distances

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 $(r \to \infty)$ is matched to the solution at the nuclear origin $(r \to 0)$. In both of these instances, it is assumed that the electron 'sees' only a pure coulomb field. Effects due to electron exchange and configuration interaction are neglected in the derivation of the F-S formula. Intuitively, however, one might expect that these neglected effects are to some extent included because of the dependence of $\Psi^2(O)$ in Eqn. (1) on empirical values of the energy levels.

It is of interest to note that the F-S formula is expected to be most successful in the case of the alkali atoms. The reason for this prediction is based on the choice of the term energy as the eigenvalue of the problem in the F-S derivation and, as is well known, the energies for the alkalis (6) are accurately given by

$$E_{n} = \frac{-1}{n_0^2} R$$
 (2)

where R is the Rydberg energy.

Finally, we mention in passing that Foldy (7) obtained a more rigorous derivation of the F-S formula by using a modified JBWK approach. Foldy's results did not produce any correction to the original F-S formula nor was he able to make any estimates of the error involved in the determination of the wave function.

More Recent Attempts

Although much theoretical work has been done recently on the evaluation of wave functions (8), the primary usefulness and success of these estimates of Ψ has been in the interpretation of energy levels. However, Klapisch (9) has reported errors of the order of 200% in certain cases in the interpretation of hfs interaction constants when self-consistent field (SCF) wave functions are employed.

There is, of course, good reason to be suspect of any SCF wave function in the interpretation of properties other than the energy. First of all, the energy depends quadratically on the wave function (10) so that a wave function in error by 10%, for example, will still produce a value for the energy

that is good to within 1%. In other words, if the trial wave function Ψ_T is written

$$\Psi_{\rm T} = \Psi + \epsilon \phi \tag{3}$$

then

$$\langle E_T \rangle = E + O(\epsilon^2)$$
 (4)

(where O (ϵ^2) indicates the order of the error) while, in general, we have for an arbitrary operator

$$\langle F_T \rangle = F + O(\epsilon)$$
 (5)

Secondly, the contribution to the energy from the wave function comes from all regions of space and even a severe oscillation of the wave function in a specified region of space (for example, the origin) will not critically affect the overall mean value of the energy (11).

S. I. Vetchinkin (12) has calculated $\Psi^2(O)$ for light atoms (Li to Ne) using a modified Ritz variational principle. A comparison of values of $\Psi^2(O)$ based on this theory and extrapolated Hartree-Fock values shows these two sets of values to differ, on

the average, by about 10%.

L. M. Delves (13) discusses a variational principle for arbitrary operators. Its relevance to the present problem lies in the fact that if the operator is chosen to be the Dirac delta function: $\delta(x - x_0)$ we have a variational principle for the wave function itself. This problem, however, was not considered by Delves.

The work of Percus and Aranoff (14) on variational principles for expectation values of physical quantities other than the energy might provide, in the future, a possible approach to the problem of

determining $\Psi^2(O)$.

Finally, the most recent efforts made toward calculating hfs parameters have been made using the many-body techniques developed largely by Brueckner (15). Calculations of this type have been carried out by R. K. Nesbet (16) on the ground state of boron and by Kelly and Ron (17) on atomic iron—both with excellent agreement with experimental results. The values obtained by Kelly and Ron represent a considerable improvement over those obtained by Watson and Freeman (18) using the traditional HF calculations. Although Nesbet's computed values were within 2% of the experimental results, the contributions to the coupling constant from the contact part of the interaction turned out to be negligible in comparison with other effects (polarization and orbital interactions). A table of values presented in Nesbet's paper comparing the calculations of several different authors for the contact parameter show severe discrepancies in this quantity. Thus, in effect, the isolation of $\Psi^2(O)$ still remains both elusive and difficult to ascertain.

Conclusion

In spite of the recognized limitations (2) of the F-S formula for $\Psi^2(O)$ it continues to receive widespread use because sufficiently good electron wave functions are still not available for heavy atoms. Nonetheless it is encouraging that theoretical predictions of nuclear magnetic moments utilizing the F-S formula are within 10%, of the experimental magnetic moments. To summarize, current theories as yet do not seem to offer any improvement over the F-S formula, while continued use of the latter, on the other hand, must be accompanied with some reservation.

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A Feasibility Study Using Conservation Webbingt as an Artificial Substrate in Macrobenthic Studies*

Abstract—A feasibility study was undertaken on a small woodland stream to test a new artificial substrate, Conservation Webbing. The purpose of the study was to evaluate how well the community collected on the substrate material mirrored the natural stream community. Four orders of aquatic insects were consistently found on the substrate material. Two of these orders, the Plecoptera and Diptera, showed a statistically significant increase in numbers with increasing time. The increase in Plecoptera was due to the development of two winter stonefly species, Allocapnia rickeri and Allocapnia virginiana. Certain species of aquatic insects were collected only from the artificial substrate. Conservation Webbing collected 63% of the fauna known to occur in the stream. It appears that the material would be suited for life history studies of certain species of aquatic insects.

Introduction

The community structure of benthic macroinvertebrates is frequently used to evaluate conditions in streams that receive agricultural, domestic or industrial effluents. Bottom organisms are ideal indicators of stream conditions because they have restricted habitat preference, low mobility, sufficiently long life cycles, and are quickly and directly affected by any deteriorating effluents which enter their environment.

The type of sampling equipment which is selected to collect macrobenthos in a given aquatic habitat depends upon the depth of the water and type of substrate. A Surber sampler is usually used to collect in shallow riffles while in deeper water one of several types of dredges may be used. Another technique of sampling which appears to be gaining wider acceptance is the use of artificial substrates.

Artificial substrates are structures which are placed in an aquatic habitat and left for a suitable period of time in order to allow colonization. Later the substrate is retrieved and the macrobenthic

animals are removed and counted. Numerous studies have been made using artificial substrates and several types of material and different techniques have been tried. Concrete structures were among those first proposed (1) and subsequently used (2-4). While these substrates appear to provide a satisfactory surface and are not easily moved in swift water, they are cumbersome, subject to coverage with silt, and breakage. Moon (5) used wire trays covered with stone, sand or weeds from the natural habitat as an artificial substrate to study the migration of the invertebrate fauna in Lake Windermere. Macan (6) found that this technique, however, did not work well in streams. Hester and Dendy (7), and Arthur and Horning (8) designed a multiple plate artificial substrate sampler from masonite. Arthur and Horning (8) found that this type of artificial substrate worked quite well in illustrating the effects of organic pollution from a municipal area on the Mississippi River and a sugar beet refinery on the Minnesota River. The better types of artificial substrates described to date appear to be the "wire basket or box" type which can be filled with a variety of materials. Wene and Wickliff (9) used wire baskets containing coarse rubble. Henson (10) also described a sampler of similar design. Mason, Anderson, and Morrison (11) used cylindrical, welded wire, chromium plated "Bar-B-Q" baskets filled with 9.1 kg of limestone rocks. Hilsenhoff (12) constructed a cylinder (12.7 cm high and 21.7 cm in diameter) with a top and bottom of galvanized wire. The cylinder was then filled with 3.6 kg of limestone rocks and mounted on a patio block (30.5 \times 40.7 \times 5.7 cm). Hilsenhoff (12) also advanced the "wire basket" concept by designing a sampler-catcher in order that the substrate fauna could not escape as the sampler was being removed from the water.

The purpose of our feasibility study was to use the "wire basket" concept to evaluate the degree to which the macrobenthic species in a small freshwater stream would colonize Conservation Webbing, the artificial substrate. Witham, et al (13) tested Conservation Webbing in a marine habitat and

[†] Trademark name of material. Available from the 3-M Corporation, New Business Ventures Division, St. Paul, Minnesota.

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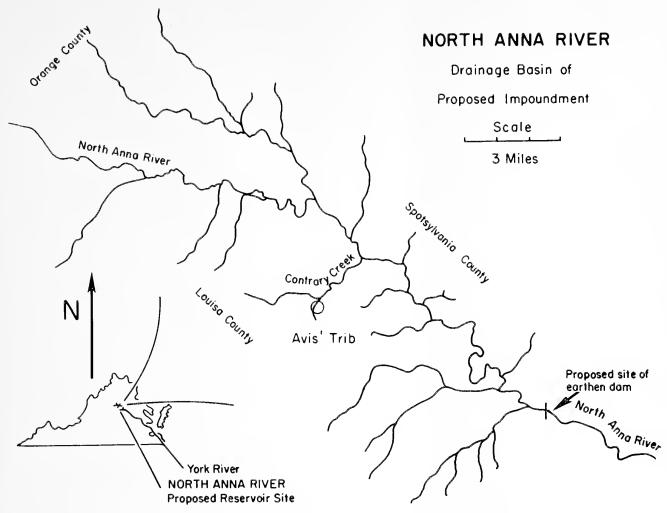


Fig. 1—Location of the study area (Avis' Trib) in the pre-impoundment area on the North Anna River.

found it highly effective in collecting postlarval forms of the spiny lobster, *Panulirus argus*.

Study Area

The study site was a tributary of Contrary Creek in Louisa County, Virginia (Fig. 1). Although Contrary Creek itself has been seriously affected by acid drainage, previous collecting on the tributary had shown that it supported a very diverse macrofaunal community. The small stream was dubbed Avis' Trib (after the junior author) by other students at the university and this name will be used hereafter in the paper for the sake of convenience.

Avis' Trib is a small woodland stream approximately 1200 feet long with a 5.4% grade from its origin to its junction with Contrary Creek. The banks are densely populated by birch although there are no trees growing in the stream bottom itself. The stream bed varies in width through the study area (approx. 200 feet) from 1 foot in some of the riffle areas to 6 feet in some of the larger pools. Flow is maintained by the natural drainage of water from the surrounding woodlands and fluctuated considerably during the study due to several rainy periods.

Methods and Materials

Physical and Chemical:

Temperatures were measured with a calibrated long-stem thermometer. The thermometer was placed in the water until equilibration was established. Turbidity values were made on a Bausch and Lomb Spectronic 20 and expressed in Jackson Units. Water samples for routine chemical analyses were collected with a sewage sampler. Oxygen was determined by the Alsterberg-Azide modification of the Winkler technique (14). Alkalinity values were determined by the potentiometric method after the establishment of a differential titration curve (14)

Biological:

Sampling the Natural Community

The natural benthic community was sampled with standard D-frame aquatic dip nets during June 1969 and 1970, and with the Surber sampler in October, 1969, at the initiation of the artificial substrate study. The 1969 dip net samples were taken near the entrance of Avis' Trib into Contrary Creek. In June,



Fig. 2—Placing the baskets containing the artificial substrates.

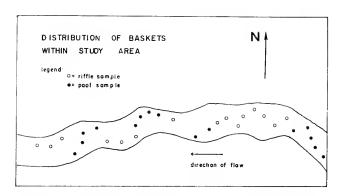


Fig. 3—Distribution of the baskets within the study area.

1970, after completion of the artificial substrate experiment, the samples were collected throughout the area where the artificial substrates had been previously placed. The square foot samples were taken before the upstream area was disturbed by the placement of the Conservation Webbing. All field collections were preserved in formalin, returned to the laboratory, washed onto a No. 30 mesh screen, and sorted under a magnified illuminator.

The Artificial Substrate

Conservation Webbing is a black thermoplastic mesh of nonwoven fibers pressed into sheets 3/8 to ½ inch thick. Four layers of the webbing were wired into the bottoms of 30, 9-inch square, aluminum baskets. The baskets were numbered and wired to stakes at intervals of four feet along the stream bed, distributed among riffle and pool areas (Fig. 2 and 3). The depth of water over the substrate material varied, but all were initially covered by an inch or more of water. Every week for ten weeks from October 21, 1969 to December 23, 1969, three numbers were chosen at random and the corresponding baskets were retrieved. The substrate mats and any detritus found in the baskets were put into isopropyl alcohol and taken back to the laboratory. Most of the organisms could be flushed out of the webbing with running water and trapped in a No. 30 mesh sieve. The rest were picked out with forceps using an illuminated magnifier. The organisms were then grouped according to order and counted.

Results and Discussion

Physical and Chemical Properties:

During the ten week period of study the water temperature changed 15 C. The initial temperature was 16 C (October 21) and the final temperature was 4 C (December 23). The lowest temperature recorded was 1 C on December 2 and the greatest changes occurred between October 21-28 with an observed drop of 8 C (16 C-8 C) and November 26-December 2 when a drop of 6 C was observed (7 C-1 C). During the first two weeks of December, ice formation was present along the margins of the stream.

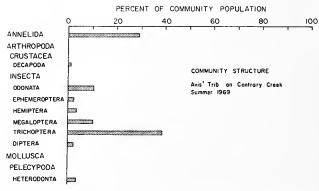


Fig. 4—Histogram of community structure on Avis' Trib, Summer, 1969.

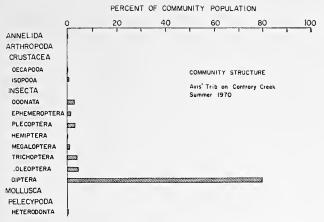


Fig. 5—Histogram of community structure on Avis' Trib, Summer, 1970.

Oxygen values varied between 7.2-11.7 ppm or 75 per cent to 102 per cent saturation. The water had a low alkalinity (11.0 ppm CaCO₃) and slightly basic properties (7.5 pH).

The Natural Community:

The community structure of Avis' Trib as evaluated by dip-netting was significantly altered between the two summers as a result of siltation due to basin clearing (Fig. 4 and 5). Clearing operations began in early 1970, and by June, 1970, all riffle and pool areas had completely filled with sand, and the extensive banks of leaf debris had been covered.

Prior to the basin clearing, one of the most abundant and diverse segments of the natural community collected with the dip nets was the Trichoptera. Other than Hydropsyche and Cheumatopsyche, the more abundant Trichopteran was Anisocentropus pyraloides. Anisocentropus pyraloides was particularly abundant along the edges of small riffle areas where a mat of birch leaves had accumulated. Wallace and Sherberger (15), in a life history study of this species, found that early instar larvae appeared to be associated with leaf drifts and late instars with logs and rocks. The representation of this order changed from 38.5% of the total community in 1969 to 4.5% in 1970 after the siltation.

The Plecoptera and Ephemeroptera were less well represented. The only Plecoptera collected was Acroneuria xanthenes, and specimens of Epeorus humeralis, Stenonema ares, Ephemerella catawba, Ephemerella deficiens represented Ephemeroptera. The representation of the Ephemeroptera changed little between the two summers. This order represented 3.0% of the community in 1969 and 2.0% in 1970. Strangely enough, the representation of the Plecoptera increased from less than 1.0% in 1969 to 4.0% in 1970.

The Odonata were well represented on Avis' Trib with specimens of Cordulegaster fasciatus, Lanthus albistylus, Boyeria vinosa, Aeshna verticalis and Agrion maculatum being collected. In 1969, the Odonata represented 10.5% of the organisms collected, but this dropped to 3.0% in 1970.

The Megaloptera also showed a drastic shift representing 10.0% of the community in 1969 but only 1.5% in 1970. Sialis, collected in 1969, was not collected in the artificial substrate zone in 1970. Nigronia serricornis was very abundant in Avis' Trib. Only one specimen of Nigronia fasciatus was collected and this specimen was taken from an artificial substrate. It was surprising to find that the dominant species of Nirgonia collected in this habitat was N. serricornis rather than N. fasciatus since the latter is restricted to cool woodland streams (16). However, N. serricornis is less discriminating in its choice of habitat (16) and more widely distributed than N. fasciatus (17). One specimen of the aquatic lepidopteran, Nymphula was also collected during the summer of 1970.

The greatest contrast seen in community structure between the two summers was in the representation of the Diptera. The representation of this order increased from 2.5% in 1969 to 80.0% in 1970. Several genera which were not collected during the 1969 summer were very common during the 1970 summer. The Chironomidac in the latter collection represented the major portion of the community in 1970. The more abundant specimens consisted of Pentaneura, Polypedilum, Procladius, and Brillia flavifrons. In addition to the Chironomidae, five different genera of Tipulidae were collected, but were represented mainly by Tipula abdominalis. Several specimens of Simulium were also collected. An increase in the Dipteran portion of the aquatic community was also noted by Aggus and Warren (18) who found that the Dipteran element "appeared to increase" after basin clearing in the Beaver Lake Basin in Arkansas.

The Coleoptera, like the Diptera and Plecoptera, increased slightly between the two sampling periods. Occupying less than 1% in 1969 the representation of the order increased to 4.5% in 1970. The Heterodonta, represented by Sphaerium striatum, decreased from 6.5% in 1969 to less than 1% in 1970.

Collections in October, 1969, with the Surber sampler in a riffle only, prior to initiating the artificial substrate experiment and before siltation from the basin clearing, showed that the standing crop of the bottom fauna community approached 14.920 animals/m². Larvae of Coleoptera (particularly Elmidac and Psephenidae) were the most abundant representing 35.5% of the total number of animals collected. The Diptera were represented mainly by members of the Tipulidae, principally Hexatoma, and represented 31.1% of the benthic community. The Trichoptera were the next most abundant and consisted mainly of Cheumatopsyche and Hydropsyche. The Trichoptera represented 20.0% of the population. The remaining components of the benthic community were represented less abundantly by the Ephemeroptera (Stenonema ares-6.6%), Odonata (Cordulegaster fasciatus and Lanthus albistylus—4.4%), Plecoptera (Acroneuria xanthenes -5.2%), Megaloptera (Nigronia serricornis— 3.0%), Hemiptera (*Merragata*—0.8%), Mollusca (*Sphaerium striatum*—3.0%), and Oligochaeta

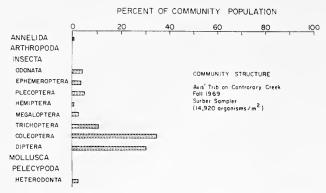


Fig. 6—Histogram of community structure on Avis' Trib, Fall, 1969.

(0.8%). Genera common to the pool areas were not represented in the square foot samples. A histogram of community structure is presented in Fig. 6.

The Community of the Artificial Substrate:

Table I summarizes the extent of colonization of the substrate by the macrobenthic community. Fig. 7 graphically represents the tabulated data. As Fig. 7 illustrates, only four orders of aquatic insects were consistently found on the artificial substrates during the ten week period of study. The degree to which the artificial substrate material collected representatives of the natural macrobenthic community can be summarized as follows: Group 1, organisms which showed a statistically significant increase in numbers with increasing time; Group 2, organisms present on the substrates throughout the study, but no increase in numbers in relationship to time; Group 3, organisms occasionally present on the substrate material; Group 4, organisms present in the natural stream community, but never collected on the substrate.

As Fig. 7 illustrates, the Plecoptera and Diptera were the only two orders of the macrobenthic community which showed a statistically significant increase in numbers with time. Additional time would be required to determine the population density at which these orders would have become stable. Other investigators (9, 11) have found that approximately 4-6 weeks are necessary for maximum colonization to be achieved. The Trichoptera and Ephemeroptera illustrated the second condition. Certain species of these orders were collected within a week and persisted at a very low density throughout the experiment. The Amphipoda, Megaloptera, and Coleoptera illustrated the third condition and probably entered occasionally to feed but not to establish residence. Members of the Annelida, Mollusca, Isopoda, Decapoda, and Odonata were never found in the baskets and exhibited the fourth condition. The Annelida, Mollusca, and Isopoda are not very abundant in this stream, but the Decapoda and Odonata are abundant.

We cannot offer any explanation at this time for the sudden drop in density on the seventh week. The only environmental factor which showed a significant change at this time was temperature. Within a week (November 26-December 2), water temperature dropped 6 C. There was no marked change in volume flow or physical disturbances within the study zone.

Conclusions about the colonization of the substrate are clouded by the fact that the baskets trapped leaves and other debris from upstream and caused enough damming to reduce the current and turn riffle areas into virtual pools (Fig. 8). If the water flow had not been affected, some of the taxa not collected may have eventually moved onto the substrate. Nearly all of the animals collected on the substrate were herbivorus. The substrate evidently offered a haven for the small, weakly swimming organisms and enough detritus was present on or within the substrate to satisfy food requirements. The relative lack of large predators in the baskets, even though the baskets were so constructed to allow even the larger crayfish to enter, and the implied extra protection offered by the substrate baskets, probably led to the marked abundance of some Plecoptera and Diptera.

We are also uncertain as to the preferential acceptance or rejection of the substrate material by the macrobenthos. Organisms would come into contact with the Conservation Webbing either through migration or drift. Whether or not there is a tactic response to remain on the substrate will require further investigation.

Fauna of the Substrate:

As Fig. 7 illustrates, the Diptera showed the greatest increase in numbers during the study period. The maximum number of animals (mean value for 3 substrates) collected during the ten week study was 89.33 animals on the ninth week. This represents approximately 1722.2 animals/m². The average density for the ten week period approximated 832.4 animals/m². The order consisted mainly of

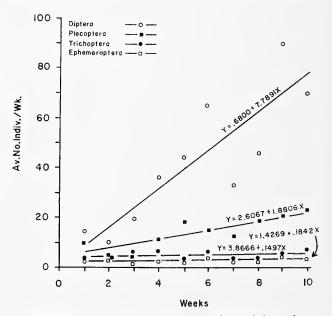


Fig. 7—The relationship between density and time of certain insect orders found on the artificial substrate.

TABLE I

Macrobenthic Species From Natural Habitat and Artificial Substrate; "X" Indicates Presence of the Species.

Organisms		D-Frame Aquatic Dip Nets		Surber Sampler	Conservation Webbing
		1969	1970	1969	
PHYLUM:	Annelida	**	7.7	**	**
CLASS: PHYLUM:	Oligochaeta Mollusca	X	X	X	X
	Pelecypoda				
CD. 100.	Sphaerium striatum	X	X	X	
	Arthropoda				
CLASS:					
ORDER:		V	v		
ORDER:	Cambarus	X	X		
ORDER.	Asellus	X			
ORDER:	Amphipoda	**			
	Gammarus				X
CLASS:	Insecta				
ORDER:		V		v	
	Cordulgaster fasciatus Lantlus albistylus	X X	X	X X	
	Aeshna verticalis	Λ	X	X	
	Boyeria vinosa	X	21	7.	
ORDER:	Agrion maculatum	X	X		
ORDER:	Ephemeroptera				
	Epeorus humeralis	X	37	V	3 2
	Stenonema ares Ephemerella deficiens	X X	X	X X	X
	Ephemerella catawba	X		Λ	
	Paraleptophlebia mollis	71			X
	Ephemerella aestiva				X
ORDER:	Plecoptera				
	Acroneuria xanthenes	X	X	X	X
	Hastaperla brevis Allocapnia rickeri				X X
	Allocapnia virginiana				X
ORDER:	Hemiptera				A
	Corixidae	X			
	Gerris	X			
OBBER	Merragata			X	
ORDER:	Magaloptera Nigronia fasciata				X
	Nirgonia jasciaiu Nirgonia serricornis	X	X	X	X
	Sialis	X	7.	Λ	74
ORDER:					
	Nymphula (-Paraponyx)		X		
ORDER:	Trichoptera	**	**	***	**
	Cheumatopsyche	X X	X X	X X	X X
	Hydropsyche Dolophilodes	X	X	A	X
	Rhyacophila vibox	X	X		X
	Drusinus	X	X		
	Lepidostoma	X	X		
	Anisocentropus pyraloides	X	X	X	
	Heteroplectron americanum Pluylocentropus	X	X		v
	Psilotreta				X X
ORDER:					A
	Psephenus herricki		X	X	
	Dryops		X	X	X
	Anchytarsus		X	X	X
ORDER:	Agabinus Diptera			X	
OKDEK.	Tipula abdonunalis		X	X	X
	Dicranota	X	X	74	X
	Limnophila		X		
	Hexat o na			X	
	Pseudolimnophila	T 7	X	**	**
	Simulium Puillia danifuona	X	v	X	X
	Brillia flavifrons Corynoneura taris		X X		X X
	Procladius		X		X
	Polypedilum		X		X
	Pentaneura		X		X



Fig. 8—An illustration showing how the presence of the baskets changed the physical habitat,

representatives of the Tipulidae and Chironomidae with the latter being the more abundant. Several genera which were collected on the substrate in large numbers were completely absent from the collections made with the Surber sampler or dip nets. An analysis of the substrates showed no relationship between the composition of genera present and location of the substrate and/or time. Corynoneura taris and Brillia flavifrons were the most abundant genera present on the substrate material. The two most abundant Chironomid predators on the substrate were Procladius and Polypedilum.

The predominant species of stoneflies collected on the substrate were *Allocapnia virginiana* and *Allocapnia rickeri*, although a few specimens of *Hastoperla brevis* were also collected. These nymphs are herbivorous and are characteristically found where leaf detritus and/or diatoms occur (19, 20). The dominance of the winter stonefly group during the substrate study and absence during other sampling periods is to be expected since their period of activity is November through March (21). The mean standing crop of these species over the ten week period was 13 nymphs/substrate or 344.4/m².

In addition to the species of caddisfly larvae collected in routine sampling, *Psilotreta* was the major form of caddisfly collected on the substrate and this genus was never taken by the other methods. *Psilotreta* has proven to be very abundant in other streams studied in the area, and it is presently unclear why its absence would be so conspicuous in routine collecting. Like *Psilotreta*, *Phylocentropus* was collected only on the artificial substrate, but occurred less frequently than *Psilotreta*. *Heteroplectron americanum*, *Drusinus* and *Lepidostoma* were the only genera collected by the other techniques which were never taken on the substrate material.

The three species of Ephemeroptera which were collected on the substrate were Stenonema ares, Paraleptophlebia mollis, and Ephemerella aestiva. The mean standing crop for these three species on the substrate was 471.6 individuals/m² for the ten week study period. The latter two species were another example of being collected only on the artificial substrate.

Summary

A feasibility study was undertaken to use a new artificial substrate material, Conservation Webbing, in an effort to determine how well the substrate community would represent the natural stream community. Approximately 43 species of macroinvertebrates were collected with D-frame aquatic dip nets and the Surber sampler in Avis' Trib on Contrary Creek. Since the artificial substrate collected approximately 27 species or 63% of the species living in the stream, it is obvious that one cannot interpret the data obtained from the substrate (diversity, community composition, or productivity) as being representative of the natural community. However, the substrate is ideally suited for life history studies of certain segments of the bottom fauna community since the substrate collects certain species of the macrobenthic community which were either not as abundant in ordinary routine sampling or missed completely. Clifford (22) pointed out that the life history approach of studying streams has not been applied extensively in North America. This substrate would facilitate this type of investigation. Another area of promising investigation is the fact that the Chironomidae are readily collected by the substrate material. Therefore, studies dealing with these organisms would be aided because they can be collected in large quantities with this material. It seems that Conservation Webbing would work well in lake studies.

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Especially for Science and Mathematics Teachers

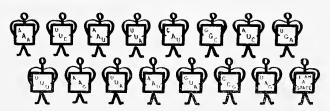
Ideas Questions Opinions

Protein Biosynthesis: A Teaching Demonstration

Some aspects of molecular biology are difficult to demonstrate, and blackboard diagrams, text charts and even models are not very effective. I use a soft-sell, corny, and very successful method to teach the elements of protein biosynthesis. The students act out roles of t-RNA, m-RNA and protein molecules. The procedure gives the opportunity for repetition of terms and immediate feedback to the instructor.

I prefer a gradual approach over several lectures, introducing concepts of polypeptide formation, structure of DNA and the essential steps of protein synthesis. In the demonstration period I spend a few minutes reviewing the adenine-thymine and cytosine-guanine pairing, substitution of uracil in m-RNA, and the complementary matching of triplet codons of the m-RNA and anticodons of the t-RNA.

In the demonstration "volunteers" are drafted when I pass out pieces of cardboard about one foot square and sheets of typing paper. The students receiving the sheets of paper are requested to assemble outside the classroom. Each sheet is numbered on one side and has a codon on the other. The students are arranged in a line according to a prcarranged sequence and then marched back into the classroom, each displaying the codon. I explain that a strand of m-RNA has been punched out by the sense strand of the DNA and is moving from the nucleus (hall) to the cytoplasm (classroom). I play the role of ribosome, announcing each codon and the class responds with the anticodon. Hesitation can easily be spotted and remedied. The correct t-RNA comes forward and stands in front of his matching codon, displaying the anticodon. The enthusiastic response of the audience in calling out the anticodons wanes rapidly; a long m-RNA sequence would be boring. When all the codons have been announced, the m-RNA molecule is in a line, with successive t-RNA's in front ranks, and the audience sees this:



The m-RNA is then asked to move off to the side and I point out that the strand will be read by the ribosome again several times before destruction takes place. The class is reminded that the t-RNA molecules are two-ended, carrying an amino acid at one end and the anticodon at the other. The t-RNA students are asked to flip the cards with this result:



This usually brings a satisfying groan.

Since those who have participated have been too close to the action to see what is happening, the sequence is repeated in more rapid style. The cards and sheets are collected and distributed among new volunteers. The m-RNA molecule is assembled in a different pre-determined order and brought into the classroom; the symbolism is again explained, and the codons are announced in rapid order. The m-RNA line is again formed with matching t-RNA in front. The m-RNA is asked to move to the side; when the t-RNA cards are flipped, the possibility of getting two short polypeptides from one m-RNA is shown:



Rather than refining the display I allow the students to point out the defects in the demonstration. Defects include a lack of a "start" codon in the first display and both "start" and "stop" in the second.

Since 16 participants are required for each demonstration the effectiveness of the demonstration is limited to classes of 30 or more. Two small classes can be combined.

The codons I used were arbitrarily selected; a more sophisticated class may demand a more meaningful assemblage.

For the second display, the m-RNA sheets are arranged in the sequence 7, 3, 4, 8, 2, 6, 1, 5.

Cards for t-RNA	Amino acid side	Р	R	О	Т	E	I	N	I am a space
	anticodon side	UUU	AAG	UUA	AAU	GUA	CCG	UAG	
Sheets for m-RNA	codon side	AAA	UUC	AAU	UUA	CAU	GGC	AUC	UGA
	number on reverse side	1	2	3	4	5	6	7	8

This demonstration has been used now in three years of college general biology classes totaling about 400 students and with three groups of high school biology students. The ultra-sophisticated student will usually humor the instructor and participate and learn something. Because of the repetition, personal involvement, and visual impact I have found this to be the quickest way to cover the material for maximum retention. In a slow-moving class this demonstration can summarize some fairly complex material. For a select class, this demonstration can serve as a starting point for discussion of genetic implications, frame-shift mutations, etc.

In the latter case, copy of codon assignments for

actual amino acids is helpful.

Grateful acknowledgement is made to Mrs. Margaret Mays of Virginia Commonwealth University who verbalized the idea of using "student molecules." Mrs. Linda Hays of Henrico High School and Mrs. Betsy Waring of the Mathematics and Science Center kindly cooperated in permitting this demonstration to be tried in their classrooms.

LEONARD O. MORROW Associate Professor of Biology Randolph-Macon College Ashland, Virginia 23005

Communications and Reports

VIRGINIA ACADEMY OF SCIENCE

Summary of Council Meeting* March 28, 1971

President Rowe called the meeting to order at 10:40 a.m. in the Larrick Student Center of MCV in Richmond.

President-Elect Turner reported committee ap-

pointments were proceeding satisfactorily.

Treasurer Grigg asked Mr. Bruner to comment on a new form, developed with the help of the new auditor, to permit current evaluation of the cashgeneral fund position. He commented on the loss of 3 business members and 2 sustaining members. There has been a slight increase in new members, a seasonal trend. The audit report has been received and records were in good order.

Ad Hoc Committee on Museum of Science

Dr. Hughes briefed Council on progress of the newly appointed Board of Trustees for the museum. A budget must be prepared to submit to the Governor by August 1. Planning for the first unit is proceeding. Mr. Midyette suggested a status or progress report furnished periodically to the Journal for publication. The Academy's Ad Hoc Committee will

Virginia Institute of Human Ecology

President Rowe stated the Governor's Council on the Environment was interested in all aspects of environment and in qualified persons throughout the State. A three man committee of Dr. Hughes, Mr. Rowe, and Mr. Charles Williams (White House staff member) has been appointed to report on the feasibility of this institute on ecology. Dr. Hughes explained it would be non-profit, private, "ecumenically" financed with a large governing board (perhaps 100) of competent persons from all segments of society. A small committee (perhaps 10) might be paid for part-time supervision of a paid staff to operate the institute. A group of associates from women's groups, industry, etc., would assist in identifying problem areas and in funding. Funding might approach five million dollars. Dr. Hughes was commended for his extensive efforts in this endeavor. Dr. Wightman moved that the Council affirm its action of November 1970 and reiterate its interest and support of this institute and that members assist with the planning and cooperate as appropriate. Motion passed.

Governor's Science Advisor

A decision from the Governor's office is expected shortly. The delay has been due to an increasing need for this person to devote a definite portion of his time to this activity.

Visiting Scientists Program

The operation of the program was discussed and suggestions made about its continued operation.

Local Arrangements

Chairman Marlowe reported dining and student center facilities will be available to all members wearing their registration badge. Senior members will be housed in the Donaldson Brown Center and Juniors in motels. Presently 16 commercial exhibit spaces are reserved.

The Engineering Section has a symposium on the Clean Air Act arranged for Friday morning. Senator Spong, Dr. Jensen of Ford, and other distinguished speakers will be panel members. President-elect Turner announced that, for various

reasons, no other symposium would be held.

Mr. Midyette moved that the Long Range Planning Committee study the scheduling of program elements of general interest including symposia so as to minimize conflicts with other activities. Motion passed.

Council expressed its sentiment for a 7:30 a.m. Friday breakfast meeting so as to have minimum conflict with the Engineering Section Symposium.

Sidney S. Negus Lecture

Dr. Nyle C. Brady, Associate Dean and Director of Research of the Experiment Station of the N. Y. College of Agriculture, Cornell University, will give the lecture on "The Role of Agriculture in Improving Environmental Quality."

Publicity

Mrs. Thelma C. Heatwole will be available to the VPI publicity office to assist in publicity since she is very knowledgeable in Academy affairs. Her expenses will be paid.

Finance and Endowment

Dr. Hughes presented a report from Dr. Harshbarger pointing out increased expenses for 1970, due in part to one journal issue being charged in 1970 rather than 1969. Midyette moved the report be accepted. Motion passed.

There were 1671 members as of March 1971.

down about 100 from 1970.

Virginia Junior Academy of Science

Chairman Wisman reported on meeting arrangements and on fund raising activities for juniors as recently authorized by the President. NSF funding ceases after this year and two business sponsors have reduced their donations.

Long Range Planning

Chairman Ulrich reported on a study of involvement of junior and community colleges with the VAS. Large fractions considered themselves active in innovative teaching and were interested in a science education section of the Academy. A fair percentage considered themselves active in some research. A need appears to exist for idea exchange among these people through the VAS annual meeting. Considerable discussion ensued on how the Academy could best meet this expressed need. Dr.

^{*} Abbreviated by the Editor from minutes provided by D. Rae Carpenter, Jr., Acting Secretary.

Carpenter volunteered to prepare a letter and send it to persons identified by the Committee and to make the Section Officers aware of this interest.

Membership

Chairman Young reported on membership information distributed to prospective members. A limited amount of Academy information is presently available. He suggested a new printing of an informational brochure and requested suggestions from Council on material to be included. The Committee will develop the information and report later. A reception at each annual meeting for potential members to meet Council was suggested as a means of covering each geographical area in a long range recruiting effort. A discussion was held about section meetings being open to non-members from the local area.

Publications

Appointment of a new Editor is necessary since Dr. Abbott's three year term expires and the Committee is presently seeking a successor. Dr. Abbott was commended for his service and regret was expressed that his other commitments precluded his reappointment. He will conclude the present volume.

Awards

Dr. Hughes announced that twenty Fellows had been nominated but only eight could be elected in 1971 (½% of present membership). The Committee will mail to the Council the entire list with eight names recommended for 1971. Council will vote by mail for eight persons.

Research

Everyone requesting support has received some but not all the money requested. Awards up to \$500 have been made. Chairman Whitehead recommended establishment of three submission dates and more extensive publicity.

Twenty papers for the Horsley Award have been submitted but half of these originally did not qualify because of the Academy membership provision. Several, but not all, have since qualified. The U. of N. C. (Raleigh) Chapter of Sigma Xi is reviewing the 1971 papers. Further clarification of the membership requirement is suggested.

Science Talent Search

Chairman Russell announced there was higher quality but lower quantity (half as many) in the 1971 applicants. Twenty-two colleges and universities are participating with scholarships but most of these are based on need rather than merit.

Trust Committee

President Rowe requested that Council be prepared at its next meeting to elect the 1971-72 Committee as provided by the new Constitution.

Journal

Phipps and Bird, under new management, has cancelled its back cover advertising space. The

Constitution and Bylaws will appear in the first issue (1971).

Ad Hoc Committee on Conservation and Natural Resources

Chairman Hughes called attention to the General Assembly's change in method of approving alterations to State parks. This now requires Assembly action rather than Executive action.

New Business

Mr. Bruner discussed the possibility of annual publication of the membership list but in a less attractive and less expensive format.

President Rowe reminded Council of a need for seeking new members. He also indicated the transfer of the Executive Secretary-Treasurer duties to Mr. Bruner with an office at the Virginia Institute of Scientific Research was essentially complete. Council was requested to consider the possibility of some future separate responsibility or position for Mr. Berry.

AMERICAN CHEMICAL SOCIETY

Southeastern Regional Meeting Nashville, Tennessee November 4–6, 1971

The meeting has several innovations which may interest you. This will be the shortest of all Southeastern Regional Meetings, beginning Thursday morning and ending at noon on Saturday. In this way, you will be able to hear papers of interest to you without losing valuable time. Only one symposium will be held, with no other meetings scheduled simultaneously, to allow all attendees to hear the Symposium speakers. Polymer Chemistry was chosen as the subject matter of the Symposium because of the large amount of activity in the Southeast Region in this field of endeavor. The eminent speakers addressing the Symposium are expected to serve as a source of cross-fertilization between the different fields of chemistry. Each will represent a major field and include Drs. H. G. Khorana (biochemistry), J. K. Stille (organic), R. G. Scott (analytical), C. G. Overberger (chemical education), and R. S. Stein (physical). This Symposium should appeal not only to the professional polymer scientist but also to chemists in general, especially teachers, since the usual college curriculum in chemistry does not cover this subject adequately. Another distinguished guest will be Prof. Max Tishler, ACS president-elect, who will preside at the one general evening meeting, which will be held Thursday, November 4.

Papers will be scheduled for Thursday and Friday afternoons and Saturday morning in the following divisions: (1) analytical, (2) applied science and industry, (3) bio- and medicinal chemistry, (4) chemical education, (5) organic, (6) physical, and (7) undergraduate research contributions.

Mr. John Bishop, Pigments Department, E. I. DuPont Company, Johnsonville, Tennessee 37174, is general chairman of the meeting.

Ecology News and Notes

ECOLOGICAL RESEARCH AT VIMS*

The Virginia Institute of Marine Science is responsible for planning and conducting basic and applied research on the environments and resources of the Commonwealth's tidal waters and adjacent waters of the Atlantic Ocean. It is also obligated to provide advisory services regarding marine environments and resources to governmental and private planners and managers and to provide education in the Marine Sciences—in affiliation with the College of William and Mary and the University of Virginia. With these responsibilities it is obvious that among the some 200 research projects in progress, it is difficult to find one that is not related to ecology or to resource-use problems.

The various research projects underway at the main campus at Gloucester Point and the branch laboratory at Wachapreague or in the James River hydraulic model at Vicksburg, Mississippi are presently divided into four major program areas:

- 1. Preservation of the marine environment.
- 2. Improved management and utilization of the marine resources.
- Biological Oceanography—understanding the biological systems of marine waters and their relationships to the physical aspects of enviornment and each other.
- 4. Physical, Chemical and Geological Oceanography—understanding the geophysical aspects of the marine environment.

Under these programs the individual projects can be categorized into about a baker's dozen subprograms, each involving several or many projects. These are:

- Ecological effects of water quality alterations on the marine environment. (11 projects)
- 2. Ecological effects of engineering modifications on the marine environment. (2 projects)
- 3. Ecology of wetlands (marshes and swamps), shorelines and shallows, i.e. productivity, nutrient and dynamic flux. (7 projects)
- 4. Eutrophication and nutrient dynamics in t'dal waters. (4 projects)
- 5. Studies of benthic communities. (6 projects)
- 6. Studies of tolerances of selected marine species to natural environmental features, i.e. salinity, temperature, amino acids, etc. and to contamination. (5 projects)

7. Biology and life histories of species important to marine ecology. (31 projects)

8. Biology and life histories of species important to commercial and recreational fisheries and also of ecological importance, i.e. striped bass, oysters, hard clams, blue crabs, etc. (28 projects)

9. Food châin studies in nursery grounds. (3 projects)

10. Research on factors influencing growth, setting and quality of molluscs. (14 proj-

11. Ecology of coelenterates—jellyfishes. (9 projects)

12. Studies of circulation of estuarine and inshore shelf waters. (16 projects)

13. Development of mathematical and hydraulic modeling of estuaries and coastal waters. (8 projects)

14. Studies of chemistry of estuarine and coastal waters. (4 projects)

15. Development of remote and *in situ* sensing of environmental features. (4 projects)

Research such as that on erosion and deposition and various other geological questions in estuarine and shelf waters, as well as other aspects, have not been included here though they are indirectly relevant. Oceanography or Marine Science deals with the marine environments and its entities and processes. As an oceanographic institute, VIMS principal efforts are therefore ecologically or environmentally relevant. Even those efforts devoted to development of new harvesting, utilization or preservation techniques are related.

As the Commonwealth's principal advisory agency for marine environments and resource matters, VIMS works closely with state, federal and local agencies and with industry to enhance, develop and preserve marine waters and the environments on which these resources and we humans depend so closely.

Among the VIMS research efforts cited above which are especially important and have received considerable public interest and involvement is the program of studies of wetland ecology specifically designed to assess the relative value of these areas and to suggest actions that may be undertaken by the Commonwealth to conserve and preserve them.

The tidal wetlands of Virginia eneompass approximately 400,000 acres, about 1% of the state's total land area. Though a very small percentage of the total, they are extremely important to productivity and quality of estuarine and coastal waters. They are also vulnerable to disruption and destruction. Significant wetlands research began at VIMS in 1968 and now involves several aspects. Work leading to production of the 154-page interim

^{*}The Virginia Academy of Science's Committee on Conservation and Natural Resources has undertaken the task of assembling items of ecological interest around the State for publication in the Journal. In this issue several research projects at Virginia institutions are reported. It will be most helpful if readers will supply further information on ecological research, education and threats. Information for the next issue should be sent to the Committee on Conservation and Natural Resources, 6300 River Road, Richmond, Virginia 23229, before September 1, 1971.

report on coastal wetlands mainly consisted of using topographic maps and some aerial photography to compile the types and areas of wetlands. Samples of vegetation were also taken to estimate the pro-

ductivity of the most characteristic plants.

Present work is directed toward better characterization and inventory of wetlands and an intensive study of Gloucester County marshes and shorelines is nearing completion. Detritus flow studies were begun in July 1970 in two marshes and a swamp and are continuing. Chemical studies on marsh vegetation, substrates and creeks are planned. Food chain studies were done by two researchers in the summer of 1970 and continuing studies are contemplated. A doctoral work on the epifauna of eelgrass was completed in 1970 and a thesis of infauna of eelgrass beds is being written.

Studies are underway to determine the ecological effects of the present levels of pesticides, polychlorinated biphenyls, heavy metals (including lead, mercury and cadmium), thermal effluents, and other wastes on marine animals and plants. Laboratory studies are used to augment field studies and to provide data which will enable the development of predictor equations for future use by management and regulatory agencies in making decisions on issues which might have adverse effects

upon the environment.

Eutrophication (a word badly used in this context), a relatively new problem in tidal waters, has resulted from the increased use of fertilizer in agriculture and by homeowners, increased use of detergents, and the increase and concentration of livestock and human populations. The resulting abnormal algal blooms reduce the aesthetic value of natural waters, degrade water quality, and may stimulate the reproduction of species which are unsuitable as food for primary consumers and increase sedimentation. Studies are underway to determine the ecological effects of overenrichment in tidal waters. These include phases on bio-stimulation, uptake, regeneration, physio-chemical removal, and transport of nutrient elements from the head of tidewater to the ocean.

Finally, of considerable interest to water quality control agencies and environmental scientists is the current VIMS program in mathematical and hydraulic modeling of estuaries. An hydraulic model of the James River, located at Vicksburg, Mississippi, is jointly operated by VIMS and the Corps of Engineers. Studies leading to development of an hydraulie model of the entire Chesapeake Bay are underway now by VIMS and its Maryland associates, the Chesapeake Biological Laboratory at Solomons and the Chesapeake Bay Institute in Baltimore. Several mathematical models of Virginia estuaries have been or are being completed in cooperation with the Division of Water Resources and the Water Control Board. All are expected to be especially useful in maintenance of water quality in specific estuaries or local portions of them. They may also prove useful to biologists in achieving a better understanding of

fish migrations, population dynamics of important species and their life cycles.

VPI'S CENTER FOR ENVIRONMENTAL STUDIES

The Center for Environmental Studies was authorized by the Board of Visitors of Virginia Polytechnic Institute and State University in May, 1970 for the purpose of providing counsel and guidance about environmental problems to the government, industry, the University, and other educational institutions of the Commonwealth and to coordinate research activities at Virginia Tech oriented toward the solution of specific environmental problems.

From the broad charter outlined by the Board of Visitors, the specific objectives of the Center for

Environmental Studies are:

1. Stimulate and encourage research directed toward solution of problems relating to the quality of the human environment.

2. Coordinate environmental research on a University-wide basis and improve communication among faculty members engaged in research related to the quality of the human environment.

3. Facilitate organization of team approaches to environmental research requiring participation of faculty members representing several disciplines,

departments, and colleges.

4. Provide logistic support for environmental studies and experiments where special field oper-

ations are necessary.

5. Establish and maintain an information center capable of providing industry, government agencies, and other institutions in Virginia with the latest information and data needed to cope with their specific problems.

6. Recommend to the Dean of the Research Division, and through him to the University Administration, steps which should be taken to strengthen disciplinary areas whose weakness may limit capabilities in problem-focused research on environ-

mental quality.

7. Maintain contact with agencies providing funds for environmental quality research and scek to match the requirements of such agencies with research interests and capabilities of University faculty.

8. Stimulate and encourage innovative curriculum development in the area of environmental

quality.

9. Arrange for strong student participation in all

research programs undertaken by the Center.

10. Work closely with the Dean, Extension Division, in planning to bring the results of Environmental Quality Research to potential users throughout the state in a form adapted to their particular needs.

11. Cooperate with the Directors of the Agricultural Experiment Station, the Water Resources Research Center, the Center for Urban and Regional Studies, and other units having overlapping or closely related missions to the end that the total

University program in this area may be fully coordinated and effectively planned and managed.

The Center for Environmental Studies serves as a nucleus around which environmental activities develop. The strength and success of the Center is dependent upon a constant interplay between the problem-focused work of the Center and the related disciplinary activities of the College Departments. The principal resource for the Center for Environmental Studies will be faculty members engaged in disciplinary work whose talents and interests fit them for participation in the Center programs.

NEW DIVISION OF AQUATIC BIOLOGY AT VISR

A Division of Aquatic Biology has been formed by the Virginia Institute for Scientific Research. This newest research division of the Institute is directed by Dr. Michael D. Dahlberg who recently came to VISR from the University of Georgia where he was responsible for a four-year study of the effect of a new paper mill on the ecology of a

Georgia estuary.

The research group is conducting both laboratory and field investigations in aquatic ecology with particular emphasis on the determination of the degree and kind of industrial use to which bodies of water can be put without degrading their quality for recreation, food production, and other uses. Involved in the development are the Departments of Biology and Chemistry of the University of Richmond, with which VISR affiliated in 1969.

VISR's Division of Aquatic Biology will be the scientific arm of a proposed Environmental Rescarch Center which may include faculty members of the business and law schools of the University

of Richmond.

VISR was founded in 1948 through the efforts of the Research Committee of the Virginia Academy of Science. The inspiration and leadership for its creation came from the late Dr. Allan T. Gwathmey, who was its President until 1963. This latest development will continue to fulfill a major objective of the Academy to attract and hold scientists in Virginia to serve the Commonwealth.

MARY WASHINGTON COLLEGE RAPPAHANNOCK RIVER PROJECT

Last fall Mary Washington College received a National Science Foundation grant of which approximately \$50,000 is being applied to their Rappahannock River Ecosystems Project. This project is a cooperative effort among the science departments. Investigations of such factors as stream flow, channel shape, substrate composition will be undertaken by the geology department. Their investigations will be correlated with studies on basic river chemistry, bio-assays, and trace element analysis by the chemistry department, and with species distribution and general population studies by the biology department.

ENVIRONMENTAL STUDIES AT SWEET BRIAR COLLEGE

In 1970 Sweet Briar College was awarded a three-year National Science Foundation grant for improvement of the social and pure sciences. A major project supported by this grant is an environmental study using the college's 3400 acres and the neighboring county as study areas for students in the sciences. The field projects will be, where possible, interdisciplinary and the basis for continuing studies when the period of the grant has terminated.

ENVIRONMENTAL UNIT FORMED

The Union Camp Corporation's paper-lumber complex in Franklin, Virginia has formed a special department for environmental protection. John D. Munford, general manager of the Bleached Paper and Board Division, announced that the unit will expand environmental activities formerly included in the processing engineering department. Technical director W. C. Chapman, who formed the department within his division, named E. V. Benedict, Jr., to head the unit, called the Environmental Engineering Department.

ECOLOGICAL PARK STUDY

A team of students at Randolph-Macon Woman's College, Lynchburg, Va., has been awarded a grant from the National Science Foundation to conduct an ecological study on the Blackwater Creek Basin in Lynchburg.

The students planned the project and will carry it out this summer over a ten to twelve week period. The data they gather will be submitted to the Lynchburg Planning Commission to add to the commission's study of a proposed 250-acre park

development in the area.

The NSF grant, which totals \$16,760, was awarded under the foundation's Student-Originated Studies Program. The stated purpose of the program is "to encourage college students to express in productive ways their concern for the environmental well-being of our nation and to provide support for groups of students who can demonstrate their readiness to assume increased responsibility for their own educational development.

The study will be directed by Anne Lindsey, a junior biology major from Bluefield, Va., assisted by Barbara Laning, also a junior biology student from Akron, Ohio. Five other R-MWC students will participate, and they hope to involve as many as 15 students, including some from other colleges and universities. Dr. Franklin F. Flint, professor of biology and department chairman, is the faculty

advisor for the project.

The student planners have set up study groups in five areas. These will be concerned with plant life, animal life, water analysis, and an ecological study group to correlate information from the others' findings. A fifth group will conduct a sociological survey of people in the surrounding urban developments to determine how they are affected by the projected park.

General Notice To Contributors

The Virginia Journal of Science heartily welcomes for consideration original articles of technical or general interest on all phases of mathematics, the natural, physical and engineering sciences. Submission of an article for publication implies that the article has not been published elsewhere while un-

der consideration by the Journal.

All articles should be typewritten (double-spaced) and submitted on good bond paper (8½ × 11 inches) in triplicate to the Editor. Margins should not be less than ½ inches on any border. Title, running title, authors, place of origin, abstract, figures, legends, tables, footnotes, and references should be on individual pages separate from the text. Technical abbreviations should follow consistent standard practices with careful avoidance of unnecessary neologistic devices. All pages (including illustrations) should be consecutively numbered in the upper right corner. A pencil notation of author names on the back of each page is helpful in identification.

Illustrations should be supplied in a form suitable for the printer with attention to the fact that a reduc-

tion in size may be necessary.

A good technical article generally contains an obligatory abstract before the text, an introduction, with reference to preliminary publications that may exist, an experimental section, results (which may be included in the experimental section), a discus-

sion, and conclusion. References are indicated in the body of the article by consecutively used numbers in parentheses. Although publication costs are high, attention should be given to relatively complete references (bibliographies) since the purpose of an article is to illuminate the significance of present and past findings, and not merely to obscure the past. The Journal reserves the right (generally exercised) to make page charges for articles in excess of 5 pages and to bill authors at cost for unusually complicated illustrative material.

Abbreviation of journals for references can be found in the 4th edition of the *World List of Scientific Periodicals*, Butterworth, Inc., Washington, D. C., 1963, and supplements. References should be checked carefully.

The form of presentation is illustrated below:

- 1. Aiyar, A. S., and Olson, R. E., Fedn Proc. Fedn Am. Socs exp. Biol., 23, 425 (1964).
- Chappell, J. B., Cohn, M., and Greville, G. D., in B. Chance (Editor), Energy linked functions of mitochondria, Academic Press, Inc., New York, 1963, p. 219.
- 3. Riley, G. A., and Haynes, R. C., Jr., *J. biol. Chem.*, **238**, 1563 (1963).

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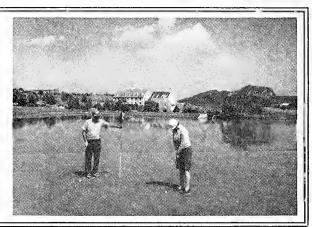
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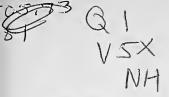
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Back issues are available for some years at \$3.00 per issue plus postage.

The front cover is by Douglas C. Hensley.

VIRGINIA ACADEMY OF SCIENCE FORTY-NINTH ANNUAL MEETING, BLACKSBURG MAY 12-14, 1971

SUMMARY OF COUNCIL MEETING AND ACADEMY CONFERENCE

Council met on Wednesday, May 12, 1971, in the Continuing Education Building at VPISU, President Rowe presiding.

LOCAL ARRANGEMENTS

Dr. Marlowe expressed appreciation to Council and to members of his Committee for the efficient way in which the Meeting was proceeding. Council in turn expressed appreciation for the hard work Dr. Marlowe and his Committee have put into making arrangements for the Meeting.

VJAS

It was reported that the Junior Academy Meetings went well and Council expressed appreciation for the tremendous job which Dr. Wisman is doing as Director of VJAS.

AWARDS COMMITTEE

Dr. Harshbarger, Chairman of the Committee, nominated the following for Fellows of the Academy: Robert Clifton Carter, Edward S. Harlow, W. T. Harnsberger, Jr., A. M. Harvill, Col. S. M. Heflin, George W. Jeffers, Harry G. M. Jopson, E. L. Wisman. Dr. Harshbarger commented that upon examination of all of the nominations which had been submitted to him, these were the ones which had been selected and that they had met all criteria for election as a Fellow of the Academy. Council passed a motion electing the names presented.

TRUSTEES

The Executive Committee recommended to Council that Lloyd C. Bird be elected as a Trustee of the Academy for a one year term and that Edward S. Harlow be elected for a three year term. Council passed a motion to this effect.

PUBLICATIONS COMMITTEE

Walter S. Flory reported that the tenure of the Editor of the Journal will expire in August of 1971. Dr. Charles H. O'Neal, biophysicist at Virginia Commonwealth University, Health Sciences Division, has agreed to accept the position as Editor beginning in September of 1972. He will be in England until August of that year and consequently cannot accept the editorship at an earlier date. Dr. Abbott has agreed to an interim appointment to fill the job until Dr. O'Neal returns from England. Motion was made and passed by Council to ac-

cept this arrangement as made by the Publications Committee.

MEMBERSHIP COMMITTEE

Mr. William Young, Membership Committee Chairman, reported on plans for an information brochure to be sent to prospective members of the Academy. Council had no further suggestions for the Membership Committee but agree that the information brochure should be prepared as reported.

MUSEUM FUND

Dr. Grigg moved that the remainder of the Museum Fund be put in a savings certificate and designated for future use for museum activities as determined by the Executive Committee. Council passed this motion.

FINANCE COMMITTEE

Dr. Boyd Harshbarger reported on the financial status of the Academy for the fiscal year 1969–1970. Dr. Harshbarger is concerned that the deficit of 1970 might be continued and should be given careful attention by Council. In the ensuing discussion it was pointed out that the main reason for the deficit in 1970 is that there were bills for five issues of the Journal in 1970 and only three in 1969. The reason for this is that the bills are paid when rendered and attributed to that fiscal year. Consequently, when one balances the expenditures of 1969 and 1970, there is only a slight deficit and at the moment does not appear to be of major concern to Council. A copy of Dr. Harshbarger's report is included in the report of the Academy Conference held on May 13, 1971.

RESOLUTIONS

Mr. Bruner passed on the request of Paul Siegel of the Resolutions Committee that each Section Representative give names of all deceased members to Dr. Siegel for inclusion in the report of that Committee to be given at the Academy Assembly.

FUND RAISING COMMITTEE

President Rowe reported that a Fund Raising Committee has been appointed with particular emphasis to be given to raising funds for the Junior Academy. This Committee is as follows: Virginia Ellett, Chairman; Bill Niemeyer; Mrs. J. J. Thaxton.

EXECUTIVE SECRETARY-TREASURER

The transition of activities from Mr. Berry to Mr. Bruner will be finalized as of June 30, 1971.

Mr. Berry moved that the Executive Committee be allowed to prepare any papers which the banks may request for the transfer of funds. This motion was passed. President Rowe complimented Mr. Berry for outstanding service to the Academy over many years. President Rowe passed to the Council the recommendation of the Executive Committee that Mr. Rodney Berry be appointed as a Consultant to Council in which position he would act as the agent of the Council in such matters as are delegated to him by the President. This would authorize the payment of Mr. Berry's expenses as he carries out those tasks assigned to him. This motion was passed by Council. Mr. Berry graciously commented that he had been well repaid in kindness and cooperation by the members of the Academy over the years.

MEMBERSHIP LIST

Mr. Bruner commented that the membership list was of continuing concern to him, that he hoped to have a list published this year.

ANNOUNCEMENTS

Dr. Abbott mentioned that the next issue of the Journal of Science will be coming out next week and pointed out the specific reasons for the delay of issue.

Dr. Rowe mentioned that he had written a letter of sympathy to Mr. Edward S. Harlow, a past president of the Academy, on the recent loss of his wife.

President Rowe expressed appreciation to all members of Council for their cooperation and serv-

ice to the Academy during the year.

Dr. Turner announced that the next Executive Committee meeting would be at 7:30 a.m., Friday morning. He also asked that all Council representatives from the Sections and that Section Chairmen and Secretaries meet with him at 5:45 p.m., on Thursday.

SUMMARY OF THE ACADEMY CONFERENCE

The Academy Conference convened at 11:30 a.m., May 13, 1971, in the auditorium of the Continuing Education Center, VPISU, Blacksburg, Virginia, President-elect Ed Turner presiding. Dr. Turner informed the Conference that the President, Maurice Rowe, had been called to Richmond by the Governor and was unable to preside at the Conference but would be at the banquet that evening to preside at the Academy Assembly. It was moved, seconded and the motion passed that the minutes of the last Academy Conference be approved as published in the Virginia Journal of Science.

REPORTS OF OFFICERS

Dr. Turner, President-elect, reported that he was happy, that he thought the Academy Meeting was going well, that there had been an unusual number of excellent papers, and that the facilities provided by the host institution were excellent. Dr. Flint, Secretary, reported that the file of the Secretary is up to date and made one request of all those members who initiated or responded to correspondence

concerning Academy business. The request was that all such persons provide the Secretary with a copy of such correspondence so that the records of the Academy maintained by the Secretary would be complete. Dr. Grigg, Treasurer, presented his report.

COMMITTEE REPORTS

The reports of the Virginia Junior Academy of Science by Dr. Wisman, the Financial Committee by Dr. Harshbarger, and the Flora Committee by Dr. Harvill were read by the Secretary. Dr. E. V. Russell gave an oral report of the Science Talent Search Committee. No other reports were ready at this time but will be published in the Journal. Dr. Turner recognized Dr. Thomas J. Marlowe as Chairman of the Local Arrangements Committee, complimented the Committee on its outstanding work, and asked for comments from Dr. Marlowe. In his comments Dr. Marlowe expressed appreciation to the members of his Committee who had worked so arduously and effectively to make the Meeting run smoothly. He singled out for specific comment Drs. Harold M. Bell, Donald G. Cochran and Thomas W. Johnson.

AAAS REPRESENTATIVE

Dr. Turner recognized Dr. Raymond Taylor who extended greetings from the AAAS. He commented that Virginia was among the first of the State Academies to have a delegate to the AAAS. He stressed the importance of good communications between the state academies and the national organization. He drew attention to the fact that he had been a member of the Virginia Academy for many years, having attended his first meeting at Hollins College in the spring of 1932 and had been with the AAAS since 1949.

NEW BUSINESS

Dr. Cole presented the slate of nominees for the Nominating Committee. This Committee consists of the immediate Past Presidents of the Academy, D. Rae Carpenter, Paul B. Siegel, in addition to Dr. Cole. The slate presented was as follows:

President-elect—Franklin F. Flint, Randolph-

Macon Woman's College Secretary—G. R. "Jack" Brooks, William and

Treasurer—Austin Grigg, University of Rich-

mond

Dr. Turner asked for nominations from the floor. There being none, it was moved, seconded and passed that nominations be closed and that an unanimous vote be cast for the slate as presented.

REPORT OF THE VIRGINIA JUNIOR ACADEMY OF SCIENCE

The Virginia Junior Academy of Science celebrates its 30th Anniversary this year. Although the number of high schools affiliating with the VJAS decreased 6% over the last year, the number of research papers submitted for the annual meeting increased 15%. A total of 200 papers was programmed for presentation at the Annual Meeting, out of 324 submitted. More important was the obvious improvement in the quality of the papers presented.

The total attendance this year was 714, of which 580 were students, 89 were teacher-sponsors, and 45 were Senior Academy supporters. These figures are slightly greater than those of last year.

In keeping with the changing times, the program shows a change in paper categories. The Astronomy and Space Science category has been replaced by a new one—Environmental Science. Last year, 5 papers were submitted in Astronomy and Space Science; this year, 35 were submitted in Environmental Science. We note that the interest of our junior scientists is no longer all "up in the stars" but rather, is turning more towards ecology and problems of "down to earth" concern.

The Committee shares the concern of the public interest in assuring proper treatment of experimental animals by our student scientists. Our action has been to acquaint all VJAS members with the principles proclaimed by the collective animal research professional societies for the proper treatment of vertebrate animals in research, and to require a signed certificate to this effect of all students

using animals in their projects.

We reflect the same budget concerns of most organizations today, i.e., tight money! Compared to last year's budget of \$7500, we have increased to \$7800, but the percent of this amount coming from the VAS, our parent organization, has increased from 33% to 41%. To change this trend, we must, with the help of the VAS, seek outside grant and gift funds. A committee is now functioning to do this.

Our overall program of activities has not changed materially from last year. We continue to publish our *Proceedings* and two issues of the *Junior Science Bulletin*, to award \$500 on student research grants sponsored by the AAAS through the VAS, and to send two participants to the AAAS meeting to present papers before the American Junior Academy

of Science.

Gratitude is expressed to the officers and members of the Senior Academy for their strong continued support of our program, and to the many other individuals and industrial firms, as well, for their financial assistance and interest in developing young scientists for the future.

E. L. Wisman, Chairman

REPORT OF THE FLORA COMMITTEE

Revisions with distributional data of several groups of Virginia plants were completed by Miles Johnson, Peter Mazzeo, and the chairman. The bibliography of Virginia botany was continued by Rebecca Bray and Gerald Levy. Aided by a grant from the Research Committee, Charles Stevens made extensive explorations of Mt. Rogers and vicinity.

Collections of Virginia plants continued to build up at a rapid pace, with the College of William and Mary alone adding more than 6000 specimens.

Again, several Virginia studies were published by members and associates.

A. M. Harvill, Jr., Chairman

REPORT OF THE RESOLUTIONS COMMITTEE

WHEREAS, the members of the Virginia Academy of Science have assembled for their 49th annual meeting on the campus of Virginia Polytechnic Institute and State University, May 11–14, 1971

THEREFORE, we, the members of the Virginia Academy of Science present the following resolutions and ask that they be spread upon the minutes of this Assembly; to wit:

BE IT RESOLVED

1. that we express our gratitude for the hospitality extended by our host Virginia Polytechnic Institute and State University,

that special appreciation go to the officers of the Academy, under the able direction of President Maurice B. Rowe, for another year

of successful operation,

3. that we hereby acknowledge our debt to the local arrangements committee and its chairman, Thomas J. Marlowe, for both their planning and implementation,

4. that we express thanks to the commercial exhibitors for their role in making this meeting

a success,

5. that we take cognizance of the challenge and stimulation of the Junior scientists during their 30th meeting which was an important part of this meeting,

6. that the Academy notes with sorrow the death of several of its members since the last an-

nual meeting.

Paul B. Siegel, Chairman

REPORT OF THE MEMBERSHIP COMMITTEE

The Membership Committee has functioned both as a whole and individually. Invitation to affiliate with the Virginia Academy of Science was extended to over 200 persons recommended by members of the Membership Committee.

Through the joint efforts of Dr. D. Rae Carpenter, Past President, Dr. Dale V. Ulrich, Chairman, Long Range Planning Committee, and the Membership Committee, invitations were also extended by letter to each member of the science and mathematics staff of all Virginia Community Colleges.

The Committee has presented to Council a proposal for new informational materials on the Academy. These materials would be designed to meet the needs of both current and prospective members.

William F. Young, Jr., Chairman

REPORT OF THE PUBLICATIONS COMMITTEE

The tenure of Dr. Lynn D. Abbott, Jr., as Editor, The Virginia Journal of Science, expires in August,

1971. Dr. Abbott has indicated that research and departmental responsibilities will prevent his accept-

ing another three-year term as Editor.

Dr. Charles H. O'Neal, Department of Biophysics, Medical College of Virginia, Virginia Commonwealth University, has accepted, with approval of Council, a three-year term as Editor of the Journal. However, Dr. O'Neal expects to be at Cambridge University, England, from August, 1971, to August, 1972, which will delay initiation of his service as Journal Editor.

Dr. Abbott has graciously agreed to extend his Editorship of the Virginia Journal of Science for an additional year—until the return of Dr. O'Neal to this country in August, 1972.

Accordingly, about September 1, 1972, Dr. O'Neal will begin a three-year term as Journal Editor.

The Virginia Academy is greatly indebted to Dr. Abbott for the magnificent job he has carried out with the Journal over the past three years, and is doubly grateful to him for his willingness to extend his Journal Editorship until August, 1972.

Some additional progress has been made with the Dismal Swamp manuscripts. Another has been published in The Journal, and still another has been accepted for publication.

Walter S. Flory, Chairman

REPORT OF THE RESEARCH COMMITTEE

During the year the Research Committee made the following awards in the following amounts:

Daniel Soneshine 12/16/70 "Computer processing for data collected on ticks infesting wild birds in the eastern United States"	Amount Requested 650.00	
N. Rice & W. Powell 12/16/70 "A comparative study of the toxins of three species of jelly-fishes occurring in Chesapeake Bay"	500.00	500.00
W. L. Mengebier 12/16/70 "In vivo experimentation with the rat as test animal"	487.40	487.40
J. F. Matta 1/21/71 "Aquatic insects of the Dismal Swamp"	250.00	250.00
R. E. Jenkins 1/26/71 "Biosystematics of two Darter species of the subgenus <i>Catonotus</i> (Pisces, Percidae), and the fishes of Copper Creek, Southeastern Virginia"	587.00	400.00
G. W. Ramsey 4/29/71 "Ecological-Floristic Survey	250.00	250.00

of the Southern Piedmont of Virginia"

E. S. Kline 4/29/71 900.00 250.00 "Nicaragua shark project"

TOTAL 3624.40 2637.40

There were 18 papers submitted in competition for the 1971 J. Shelton Horsley Award. The North Carolina State University Chapter of Sigma Xi were the judges and the winning paper was "The Unusual Electrical Effects in Arsenic-Tellurium semiconducting Glasses" submitted in the Materials Science section and authored by L. R. Durden, L. H. Slack, and P. R. Eusner.

W. D. Whitehead, Chairman

REPORT OF THE SCIENCE TALENT SEARCH COMMITTEE

All the students from Virginia who participated in the 30th Science Talent Search for the Westinghouse Science Scholarships and awards, as conducted by the Science Clubs of America were automatically considered in the Virginia Science Talent Search.

Students from 49 states and the District of Columbia completed entries in the 30th National Science Talent Search. Forty-two states and the District of Columbia scheduled State Science Talent Searches

this year.

Virginia had 50 completed entries in the National competition this year as contrasted with 116 last year. These 50 entries were from 23 different high schools. (Last year we had entries from 49 different high schools). From the 50 entries we had 8 students in the National Honors Group (16.0% as compared with last year's 17.2%) (300 are selected from the Nation). From the 8 students in the National Honors Group we had 3 students in the National Winners (Forty were selected as National Winners from the Nation).

Virginia ranked 9th out of the Nation (49+D.C.) in number of students in the Honors Group and tied for 4th along with Florida for the number of students as the National Winners this year. On the basis of students in the National competition Virginia ranks well in the top 10 in the nation.

The 50 entries were reviewed by the reading committee and thirty-five were selected as Virginia Finalists and invited to the annual meeting of the Academy. Thirty-two attended and were interviewed. Fifteen were selected as Virginia Winners.

Each contestant was given \$10.00 (coordinates with the Junior Academy participants to prevent duplication) to help with food expenses. The 15 winners were given \$15.00 each to be applied to the purchase of a scientific handbook.

Edgar V. Russell, Jr., Chairman

REPORT OF THE AGRICULTURAL SCIENCES SECTION

The Agricultural Sciences Section held a 2 day session May 13-14 at the Donaldson Brown Con-

tinuing Education Center, VPISU. Forty-five (45) papers were sponsored or presented by members along with a VJAS award paper. "Chemical Retardants for Salt Toxicity" by Miss Linda Cox of William Byrd High School, Vinton.

The following officers were elected: Chairman Dr. K. P. Bovard; Vice-Chairman, M. W. Alexander; Secretary, Dr. D. E. Petty; and Councilman, T. G. Copeland, Jr.

The agricultural section lost one member by death, Mr. Carroll Bass.

Morris W. Alexander, Secretary

REPORT OF THE BIOLOGY SECTION

Members of the Biology Section were quite active research-wise during the year. Research activities culminated in the presentation of 59 papers at the May, 1971 meeting. This number compares with 41 papers presented at the 1970 meeting and 37 papers presented at the 1969 meeting.

Members served as officers of the Academy, Section Chairmen and judges in the Virginia Junior Academy and served as members of various Academy committees. In addition, many members judged in local and regional science fairs and have helped in the efforts to establish a state science museum.

Officers elected for 1971-72 were: Chairman, Dr. George M. Simmons, Virginia Commonwealth University; Vice-Chairman, (the section declined to elect this office); Secretary, Dr. Gerald Llewellyn, Virginia Commonwealth University; Council, Dr. Warwick R. West, Jr., University of Richmond (to fill the one-year unexpired term of Dr. G. S. Grooks, Jr.)

Philip C. Lee, Jr., Chairman

REPORT OF THE BOTANY SECTION

The 1971 Annual Meeting was the first in which the Botany Section officially existed, it having met last year as a trial session. A total of 23 contributed and 2 invited papers were scheduled, representing most major areas of plant science. Attendance at the paper sessions was consistently high, reaching a peak of 55 and never dropping below 14. Average attendance per paper at the Thursday morning, Thursday afternoon, and Friday morning sessions was 29, 44, and 20 respectively. A total of 63 people signed the register of attendance. Officers for the next year are Dr. Rebecca D. Bray, Old Dominion University, Chairman; Dr. Dorothy C. Bliss, Randolph-Macon Woman's College, Vice-Chairman; Dr. R. Jay Stipes, VPISU, Secretary; and Dr. Leonard O. Morrow, Randolph-Macon College, continues as Council Representative.

Stewart Ware, Chairman

REPORT OF THE CHEMISTRY SECTION

The program of the Chemistry Section this year consisted of a total of 44 papers, 43 from academie institutions from all areas of the state and one from the Virginia Institute for Scientific Research.

The new officers elected at the business meeting are as follows:

Chairman, Dr. John G. Mason Secretary, Dr. Homer Smith Editor, Robert G. Bass

No problems have been presented which require Council action.

Randolph Gladding, Councilman

REPORT OF THE ENGINEERING SECTION

The annual business meeting of the section was held May 13, 1971 in Blacksburg, Virginia at which time new officers were elected. The officers for 1971-72 are as follows: Chairman, F. C. McCormick, University of Virginia; Vice-Chairman, D. L. Michelsen, VPISU; Secretary, E. G. Keshock, Old Dominion University; Editor, M. N. Bishara, Southwestern Community College.

During the year, Mr. Charles Chandler was dropped as a continuing member of the executive committee, because he has relocated, and the committee added Mr. Gilbert R. Shockley, Reynolds Metals Company. The executive committee now consists of the officers of the section and the following continuing members: Mr. Stanley Ragone, Section Councilor; Dr. G. A. McAlpine, Industry Contact Member; Mr. Auzville Jackson, Jr., Industry Representative; and Mr. Gilbert R. Shockley, Industry Representative.

The section presented its annual Industry Achievement Award to Mr. Harold H. Macklin, Products Development Division, Reynolds Metals Company.

The annual meeting of the section was held in Blacksburg, Va., on May 13-14, and consisted of two general paper sessions and a symposium dealing with the Clean Air Act.

Robert D. Krebs, Chairman

REPORT OF THE GEOLOGY SECTION

At the annual meeting of the Virginia Academy of Science in Blacksburg on May 13–14, thirty-one papers were presented before the Geology Section. The paper sessions were attended by approximately sixty people. The following people were elected as officers of the Geology Section for 1971-72. Chairman—O. S. McGuire; Vice-Chairman—G. A. Bollinger; Secretary—R. S. Spencer; Field Conference Chairman—R. S. Ellison.

The Geology Section again sponsored the Virginia Geological Field Conference. The second annual meeting of this Field Conference was hosted by E. W. Spencer and the staff of the Department of Geology at Washington and Lee University on October 3rd. Approximately 100 geologists participated in the field trip which dealt with the geology of the Blue Ridge and the Valley and Ridge in Virginia.

Several members of the Geology Section participated in the Visiting Scientist program of the Academy and gave talks at elementary and secondary schools throughout the Commonwealth of Vir-

ginia.

Bruce K. Goodwin, Chairman

REPORT OF THE MATERIALS SCIENCE SECTION

Our session had a record number of papers, 36, and for the first time our session lasted two days. A very wide range of topics in materials science was discussed. Practically all of the papers dealt with metals, ceramics, semiconductors or polymers.

A short business meeting was held to elect a new editor and a new councilman. They are K. L. Reifsnider and J. O. Lytton, respectively, both at VPISU.

Lyle H. Slack, Chairman

REPORT OF THE MEDICAL SCIENCES SECTION

The activities of this section centered around 2 major goals: a) to recruit more members and b) to arouse more interest among graduate students.

Last year we awarded three prizes (\$50.00, 25.00, and 15.00) to the best graduate student papers presented. The location of Richmond was conducive to very heavy and good participation. The program at Blacksburg again demonstrated that only real old time supporters would make the trip to such a remote location. The program at Blacksburg was good, however, and while attendance was 1/3 that of Richmond, the meeting has to be considered successful. We are planning for this year a more active membership drive; a financial drive; and more advertising to get better student participation from the colleges.

Hugo R. Seibel, Chairman

REPORT OF THE MICROBIOLOGY SECTION

At the request of the North Carolina branch of the American Society for Microbiology, a joint meeting was held with that group by the Microbiology Section. A number of papers were presented by members of both groups during the scientific session. Reports of officers and committees were approved during the business meeting. Plans for another joint meeting with the North Carolina group were discussed and tentatively approved.

During the year, officers of the Microbiology Section helped in the judging of Science Fairs in the high schools. The secretary took care of the fairs in the eastern part of the state; the president helped

with those in the west.

The Microbiology Section held a session during the meeting of the Virginia Academy of Science at Blacksburg. Thirteen papers were presented during the scientific session. Attendance varied from 10 to 35. An education committee, composed of Drs. Smith Shadomy, Harry Dalton, Richard Cribbs, and Aletha Markusen was appointed. The membership of other committees was continued. Because officers of the Microbiology Section serve two-year terms, election of officers was not held at this meeting.

Lewis D. S. Smith, Chairman

REPORT OF THE PSYCHOLOGY SECTION

Kenneth A. Blick was appointed to serve as Editor for the section, to replace William H. Leftwich, who has served ably for many years.

The response of the members to the call for papers for the 1971 meeting was very good. There were 30 research papers at the session, requiring two full days for presentation. These papers were delivered by participants from 13 different colleges and universities, some of which to my knowledge had not sent representatives to the Academy previously. In addition, the winning VJAS paper was presented, and an invited address was delivered to the section.

At the business meeting, new officers were elected. These were Donald Witters, Bridgewater College, Chairman; and David Elmes, Washington and Lee University, Secretary. It was decided to discontinue the election of an Executive Committeeman. since the office was not functional. It was further decided that the retiring chairman should write to each chairman of a psychology department in the State to inform them of the suggestion of the business session that the host institution for the Virginia Academy of Science meeting be given formal responsibility for certain aspects of the program. Although the section secretary would retain responsibility for the program, the members from the host institution would be expected to provide "special" attractions, such as invited addresses or symposiums, and chairmen for the paper-reading sessions. Also, they would be expected to encourage attendance of local persons to ensure that all paper-reading sessions were well attended. The new chairman would follow up these suggestions with his own letter later in the year before the final program for next year was completed.

E. Rae Harcum, Chairman

REPORT OF THE AWARDS COMMITTEE

Dr. Horton H. Hobbs, Jr. was presented the Virginia Academy of Science Ivey F. Lewis Distinguished Service Award.

The following members of the Academy were elected as "Fellows":

- Dr. Robert Clifton Carter, VPISU, Blacksburg, Virginia 24061
- Mr. Edward S. Harlow, The American Tobacco Co., Virginia Branch, 26th & Cary Sts., Richmond, Virginia 23223
- Dr. W. T. Harnsberger, Jr., Madison College, Harrisonburg, Virginia 22801
- Dr. A. M. Harvill, Jr., Longwood College, Farmville, Virginia 23901
- Dr. George W. Jeffers, Route 6, Farmville, Virginia 23901
- Col. S. M. Heflin, 508 Highland Road, Lexington, Virginia 24450
- Dr. Harry G. M. Jobson, Bridgewater College, Bridgewater, Virginia
- Dr. E. L. Wisman, VPISU, Blacksburg, Virginia 24061

Boyd Harshbarger, Chairman

FINANCE AND ENDOWMENT COMMITTEE FINANCIAL REPORT

Virginia Academy of Science—General Fund Income—Year ended December 31

Dues—applicable to the year	1969	1970
Student members	200	213
Regular members	6,925	6,767
Contributing members	1,570	1,520
Sustaining members	1,550	1,325
Life members		150
Business members	3,600	3,500
Delinquent members	15	19
Deduct—Above dues collected	13,860	13,494
in prior year	9,145	7,731
	4,715	5,763
Prepaid member dues	7,721	5,222
Annual meeting income	4,688	5,366
Va. Jour. of Sci. income	5,510	5,885
Gifts and Grants	1,607	2,600
Dividends and Interest	1,171	1,609
Miscellaneous	768	743
Total Ordinary Income	26,180	27,188
Legacy-Foley F. Smith (Added to Academy reserve funds)	8,000	
Total Income	34,180	27,188

Disbursements—Year ended December 31

	1969	1970
Annual Meeting Expenses	1,425	1,934
Auditing and Tax Services	946	860
Exec. Sec'y—Treas. Office		
Salaries and Expenses	3,818	5,684
Awards	150	150
Printing	1,488	2,084
Va. Journal of Science*	5,818	14,043
Va. Jr. Academy of Science	5,430	6,241
Taxes	77	209
AAAS Awards—Dues—Meetin	ng	
Expenses	173	872
Science Talent Search and		
Visiting Scientist Program	1,205	866
Miscellaneous	93	84
Total Expenses	20,623	33,027

^{*} Note—Since publication dates and bill payments have not been consistent, expenses on a year to year basis are not directly comparable.

Summary Statement

	1969	1970
Total Ordinary Income	26,180	
Total Ordinary Expenses	20,623	33,027
Surplus—(Deficit) Add Special Item—Smith	5,557	(5,839)
Legacy	8,000	_
	13,557	(5,839)
Boyd Harshbarger, Chairman		

Abstracts of Papers

Section of Agricultural Science

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

GROWTH HABIT AND ROW PATTERN EFFECTS ON YIELD AND MARKET GRADE OF THREE VIRGINIA PEANUTS. M. W. Alexander. Tidewater Res. Sta., Va. Polytechnic Inst. & State Univ., Holland, Va. 23391

A Virginia type peanut line, Va. 67-189, along with a commercial cultivar 'Va. 61R', was evaluated for performance in 4 planting row patterns, giving 2 plant populations and harvested at 2 dates. Row patterns were: high population, 2 rows 36"-2" in drill, 3 rows 18"-3" in drill; low population, 2 rows 36"-6" in drill, and 3 rows 18"-9" in drill. The Va. 67-189, having sparce vegetative growth and fruit concentrated around the taproot, yielded higher when harvested early, however, the only significant difference noted between row patterns was with a lower yield in 3 rows planted 18" apart and 9" in the drill. The highest yield at the 2nd harvest was with the high population. Va. 61R showed no significant difference due to row pattern at both harvest dates. Percent sound mature seed was reduced when planted at the high population in 2 rows 36" apart 2" in the drill. No difference in extra large seed was obtained at 1st harvest, however, at 2nd harvest, lower extra large were obtained at high population and 2 rows 36" apart 2" in drill. When yield and market grade factors are combined to obtain a value, the highest value for Va. 67-189 was obtained at the 1st harvest, low population and row pattern of 2 rows planted 36" apart 6" in the drill. When harvested late, the highest yield was obtained with the high population and 3 rows 18" apart 3" in the drill.

EFFECTIVENESS OF PARROTFEATHER FOR ATRAZINE REMOVAL FROM WATER. S. W. Bingham, <u>J. P. Valentine</u> and R. W. Schumacher* Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

Parrotfeather shoot cuttings rooted in vermiculite for 10 days were transplanted to pint jars (5 plants/jar) containing 1/2-strength Hoagland's solution 8 days before starting removal studies. Atrazine $^{-14}\mathrm{C}$ was introduced at 0, 1X 10^{-7} , 1 X 10^{-6} , and 1 X 10^{-5} molar concentrations in 400 ml per jar. At various intervals, samples were removed to determine the amount of chemical remaining in solution.

All plants were harvested at 20 days. Up to 28% of the atrazine initially present was removed from cultures with plants as compared to only a 3% loss in cultures without plants. This 3% represented loss due to sampling and volatility.

The plants in cultures of intermediate atrazine concentration were more effecient at removal than those of higher or lower levels. This research was supported by the Office of Water Resources Research, Department of the Interior, Project No. A-033-VA.

THE INFLUENCE OF SEX PHEROMONES ON MATING BEHAVIOR AND SAWFLY POPULATIONS. Marvin L. Bobb. Va. Poly. Inst. and State Univ., Res. Div., Piedmont Res. Lab., Charlottesville, Va. 22901.

Rise and decline in sawfly populations have been attributed most frequently to the influence of natural control factors. However, data obtained from 1963 through 1970 indicate that population densities are due to the sex attractiveness of the female sawfly. It was shown that the female emits a potent sex pheromone which was apparently necessary for mating. Unmated females oviposited only 17.0 percent of their egg potential; whereas mated females oviposited more than 90 percent of their total egg complement. Severe tree defoliation occurred when more that 50 percent of the females mated.

During 1959 and 1960 a very high percentage of the females mated and deposited eggs, resulting in extremely high populations of larvae which caused severe defoliation of pine forest. From 1962 through 1966 only a small percentage of the females mated and the number of eggs deposited decreased to such an extent that only non-injurious persistent populations remained. Since 1967, however, larger numbers of females have mated in some areas of Va. and there has been in increase in Neodiprion prattipopulations.

VARIATION IN SEVEN PESTICIDE RESIDUES IN APPLE POMACE. K. P. Bovard, F. D. Griffith and B. M. Priode. VPI&SU, Va. Dept. of Agriculture & Commerce and U. S. Dept. of Agriculture, Front Royal, Richmond and Front Royal.

Duplicate one-pound samples of wet apple pomace were obtained in October 1968 from 14 truck loads of apple pomace used in a feeding study with pregnant and lactating beef cows in confinement at the Beef Cattle Research Station, Front Royal, Va., during the winter of 1968-69. From analyses by the VDAC regulatory laboratory, mean pesticide content (ppm) and its standard error between samples within trucks, resp., were: Acaralate: 0.50, 0.20; DDT: 2.27, 0.78; DDE: 0.15, 0.05; TDE: 0.12, 0.09; ethion: 0.32, 0.20; BHC: 0.05, 0.04; and, Kelthane: 1.43, 1.28. Statistically, differences among loads were P < .01 for the first four, P < .05 for the fifth, and non-significant for the last two pesticides listed. Observed variability in this study supports continued restriction or regulation against feeding of apple pomace known to contain certain pesticides, especially those with zero tolerance.

EFFECTS OF TIMING AND BREEDING ON LEGIBILITY OF FREEZE BRANDS IN BEEF HEIFERS. K. P. Bovard, N. W. Hooven and B. M. Priode. VPI&SU and U. S. Dept. of Agriculture, Front Royal, Beltsville, Md., and Front Royal.

Two years' results are reported. In November 1969, twenty 8-month old Angus heifer calves were freeze-branded using copper alloy irons 3"x1"x4" cooled with liquid nitrogen. Hidecontact exposure times were 25, 30, 35 or 40 seconds for each of 5 digits applied to the hip and upper rib area of each calf. Average legibilities in April 1970 were 2.8, 6.3, 11.0 and 13.0, respectively; in November 1970, they were 6.5, 7.5, 11.6 and 13.0, respectively, where perfect legibility would be 15.0. Average legibility scores improved with increasing exposure times (P <.05) and from April to November (P <.10). In November 1970, thirty-seven 8-month old Angus heifers were similarly freeze-branded using 30, 40 or 50 seconds exposure for each of 6 digits applied. In April 1971, average legibilities were 4.0, 5.9, and 5.7, respectively, where a perfect score would be 6.0. Heifers in the latter study were cross-classified by mating system as inbred (n = 10), line-cross (n = 15) or growth selection (n = 12), with average freeze-brand legibility scores of 5.2, 4.8 and 5.5, resp. Results from 40 and 50 seconds' hide contact with cold irons were clearly superior to those from shorter times.

PATTERNS OF GROWTH, FATTENING AND REPRODUCTIVE DEVELOPMENT IN HEIFER CALVES TO ONE YEAR. <u>K. P. Bovard</u>, T. N. Meacham and B. M. Priode. VPI&SU and U. S. Dept. of Agriculture, Front Royal, Blacksburg, and Front Royal.

Beginning at weaning in October 1969 the reproductive development of 23 inbred, 11 type selection, and 14 growth selection Angus heifers, group-fed in two lots, was checked by rectal palpation of the tract at bimonthly intervals. Each heifer's stage of reproductive development, called puberty score, was classified as: zero: too small to examine; one: prepuberal; or, two: puberal, and believed to be cycling. Beginning in late December, a vasectomized bull was used to identify heifers in estrus. Concomitant data included weight (lbs.), subjective condition scores, ultrasonic estimates of fat thickness, and skeletal measurements of wither height and body length. Average puberty scores for inbreds and growth-selected heifers were 0.3 and 0.7 in October (age 212 days), and 1.0 and 1.5, resp., in March (352 days). Correspondin weights were 374 and 455 in October; 575 and 694 in March, Corresponding resp. Corresponding estimates of ultrasonic fat thickness (mm.) at a point behind the 12th rib and 4 inches off the midline were 2.65 and 2.61 in October; 3.91 and 3.50 in March, resp. Growth-selected heifers showed earlier reproductive development, more rapid physical growth, and apparently less fattening than did the inbreds. Results of heifers selected on type score were generally intermediate.

BREED AND SEX DIFFERENCES IN MEANS AND REPEATABILITIES OF ULTRASONIC READINGS OF HIDE AND FAT THICKNESS IN BEEF CALVES 6 - 12 MONTHS OLD. K. P. Bovard, R. L. Wilson and B. M. Priode. VPI&SU and U. S. Dept. of Agriculture, Front Royal, Beltsville, Md., and Front Royal.

Within one month after weaning in October 1970, four independent ultrasonic estimates, each, of thickness of hide and hide plus fat were made at a point 4 inches off the midline and behind the 12th rib on 82 bull and 80 heifer calves on a postweaning feeding test in a breeding experiment at the Beef Cattle Research Station, Front Royal. The first two readings were made prior to clipping of the hair coat at the site of the ultrasonic measurement; the second two, afterwards. L.S. analyses of the estimates of hide, hide plus fat, and fat showed nonsignificant differences due to clippings and readings; highly significant differences (P <.01) due to sex (S), breed (B), and calves/SB; the SxB interaction was non-significant for all three variables. Heifer calves showed 0.48 mm. thicker hides and 0.20 mm. more fat than did bulls, with the overall means of both sexes being 4.87, and 1.46, resp. Repeatabilities of estimates of fat thickness calculated as intraclass correlations from $\sigma_{C:SE}^{c}/(\sigma_{C:SE}^{c} + \sigma_{E}^{c})$ were 0.78 using data from clipped readings, whereas that for the unclipped data was 0.63. Only in technical studies would the additional gain in accuracy justify the additional cost incurred by clipping. Finding highly significant dif-ferences (P<.01) among lines in fatness supports use of such data in beef improvement.

EFFECT OF LEVELS OF UREA AND ENERGY ON ADAPTATION TO UREA FEEDING IN LAMBS. R. J. Buehler*, K. E. Webb, Jr.*, and J. P. Fontenot. Dept. of Animal Science, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061

Inst. and State Univ., Blacksburg, Va. 24061
A metabolism trial consisting of six 10-day collection periods was conducted to study the effect of high dietary urea and energy levels on nitrogen metabolism in lambs. Four semi-purified diets were fed containing 9.4% soy, 2.6% urea, 6.75% urea-low energy or 6.75% urea-high energy. Crude protein contents of these diets were 9, 9, 21 and 21%, respectively. The calculated TDN contents of the diets were 69, 69, 69 and 74%, respectively. Nitrogen retention was higher (P<.01) for the 6.75% urea diets, regardless of energy concentration. Adaptation to urea feeding appeared to be absent in the lambs fed these rations. Apparent digestibilities of dry matter, ether extract, NFE and crude protein were higher in all lambs fed 6.75% urea. Ruminal butyric acid levels were significantly higher in lambs fed 9.4% soy than in those fed the urea rations. The protein nitrogen concentration of the ruminal fluid was highest (P<.01) in the lambs consuming the 6.75% urea diets followed in order by those fed 2.6% urea and 9.4% soy. Levels of plasma free lysine, isoleucine and leucine tended to be lower in all lambs receiving urea. Blood urea was highest for the 6.75% urea diets, intermediate for 2.6% urea and lowest for 9.4% soy.

EFFECT OF PLANT SPACING ON LEE SOYBEANS. <u>H. M. Camper, Jr.</u>* and T. J. Smith, Dept. of Agron., Va. Polytechnic Inst. and State University, Blacksburg, Va. 24061

Lee soybeans were grown in rows spaced three feet apart with plants spaced $1\frac{1}{2}$, 3, 6, and 9 inches in the row during 4 production years.

Closer plant spacing was negatively correlated with seeds per plant, increased branching and pods closer to the ground; and positively correlated with larger seed, increased height and increased lodging. Plant spacing in the row had no effect upon seed yield.

MOLECULAR DENSITY AND ABSORBANCY RED PEAK OF CHLOROPHYLL a IN SOLUTION FILM AND CRYSTALLINE STATES. G. Colmano, Dept. of Veterinary Science, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 24061.

A model, combining the absorption spectra of chlorophyll a in solution, film and crystalline states, with the molecular orientation of these states, was constructed and coupled with quantum chemistry techniques. It is shown, that the knowledge of the physical parameters of chlorophyll a in different spatial orientation may explain the correlation of peak position of the red absorption for molecules in solution, film and crystalline states, with the intermolecular distance, which is inversely proportional to the molecular radius.

THE CRYOSTAT, A USEFUL TOOL IN PLANT HISTOPATHOLOGY.

C. R. Drake. Dept. of Plant Pathology and Physiology,
Va. Polytechnic Inst. and State Univ., Blacksburg, Va.
24061

Fresh apple leaves, fruit and fruit pedicels infected with apple scab (<u>Venturia inaequalis</u>) were sectioned with a cryostat microtome. The specimens were frozen in Tissue-Tek embedding medium in the cryostat until ready to cut at -19 C. The sections 12 to 15 μ thick were removed from the knife with a glass slide that had been coated previously with gelatin adhesive. The slide was placed on a slide warmer and the sections covered with distilled water. After the sections had extended fully, the excess water was blotted with a moist towel pressing downward. The slide was allowed to dry 4-12 hr then washed in water to remove excess embedding medium. The fresh sections were then stained in the same sequence as paraffin sections. Good conformation of the tissue and protoplasm were maintained. Fungal structures were well differentiated. There was good differentiation of host-parasite tissues with acid or basic fuchsin and fast green as well as with other dyes. Specimens were collected, sectioned, stained and photographed within a period of 12-36 hr. Cryostat sections have remained in good condition for a period of 3 years.

RESPONSE OF FLIES TO SONIC ENERGY. U. F. Earp and J. M. Stanley. Agricultural Engineering Dept., VPI&SU, Blacks-burg, Va. 24061 and Agricultural Engineering Res. Div., ARS-USDA

Houseflies, Musca domestica L., were subjected to a sound pressure level of 85 db at 19 frequencies in the 100 to 20,000 Hz range and to 11 frequencies in the 25 to 100 kHz range. Each sample, consisting of approximately 100 flies 3 days old, was injected into the center of a 4-foot long cage. The sonic energy stimulus was alternated between the ends of the cage. After a 5-minute test period those in each section of the cage were counted visually. Flies were neither attracted to nor repelled by the sonic energy.

STUDIES OF PROCESSING, NUTRITIONAL VALUE AND PALATABILITY OF BROILER LITTER FOR RUMINANTS, J. P. Fontenot, K. E. Webb, Jr.* B. W. Harmon*, R. E. Tucker* and W. E. C. Moore*. Dept. of Animal Science, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Of the processing methods tested, the use of dry heat at 150°C for 4 hours or longer was the only method which was consistently effective in sterilizing broiler litter. The use of dry heat at 100 or 150°C resulted in a substantial decrease in crude protein content. Samples were obtained from broiler houses in the three main broiler areas in Virginia. There was considerable variation in the chemical composition of the samples obtained from different areas. There was over a 3-fold difference in crude protein content. No substantial amounts of pesticide residues were detected in broiler litter or in tissue from animals fed processed litter. The relative acceptability of rations containing different levels of processed litter was studied using steers allowed access to rations, "cafeteria style". The amount consumed decreased as the percentage of litter in the ration increased. With individually-fed steers, during the first 50 days cattle fed 25% litter consumed 12% less feed than those fed the control ration but there was no difference during the last 70 days. Feed intake was substantially lower for cattle fed a ration containing 50% litter.

GENERAL COMBINING ABILITY AND MATERNAL EFFECTS IN CROSSING THREE BRITISH BREEDS OF BEEF CATTLE. J. A. Gaines, G. V. Richardson, R. C. Carter, W. H. McClure. Va. Polytechnic Inst. & State Univ. and U. S. Dept. of Agriculture, Animal Science Dept., Blacksburg, Virginia 24061

Data from 469 calves were used to study heterosis, general combining ability (GCA) and maternal effects using least squares. Breeds were Angus, Hereford and Shorthorn and traits were birth weight, weaning grade, weaning weight, ADG on feed, slaughter grade and slaughter weight.

Breed differences in GCA were significant (P<.05) for birth and weaning weights of all calves, and slaughter grade and weight of steers, indicating more variability among the breeds in genes influencing weight than in those for grade. The GCA interaction with system of mating was generally nonsignificant, indicating the additive effects followed the same pattern whether in two-breed or backcross combination.

The effect of breed of dam on the two-breed and backcross calves was highly significant (P<.01) for weaning weight. Moreover, these maternal effects were significantly different in the two systems of mating, indicating breed of dam differences depending on the kind of calves they were rearing.

RELATION OF THE INHIBITION OF ASPERGILLUS FLAVUS COLONY DEVELOPMENT ON A SELECTIVE MEDIUM TO RECOVERY FROM ARTIFICIALLY AND NATURALLY INFESTED SOILS. G. J. Griffin, R. H. Ford*, and K. H. Garren*, Va. Polytechnic Inst. & State Univ. and U.S. Dept. of Agriculture, Blacksburg and Holland, Va.

A peptone-glucose mineral salts medium(M) modified from Martin was supplemented with 3% NaCl (M3S), 3% NaCl plus 1 ppm Botran(M3SB), 33 ppm rose bengal(MR), 3% NaCl plus 33 ppm rose bengal(M3SR) or 10% NaCl plus 33 ppm rose bengal (M10SR) for isolation of A. flavus-A. parasiticus (FP) from artificially infested soil and naturally infested field soil by the dilution plate technique. In axenic studies the rate of colony growth of five clones of FP was stimulated when M was supplemented with NaCl concentrations up to 3%. Compared to M3S colony growth rate of all clones was slightly depressed on M3SB, and greatly depressed on M3SR; however, conidial germination was complete on all media. Recovery of FP from artificially infested soil at 10⁻³ dilution increased in the following order: M3SB>M3SR>M3S. However, recovery of FP from naturally infested soil at 10^{-1} dilution was approximately the same on M3SB and M3SR; populations in dif-ferent samples of field soil ranged from 2.2 to 13.4 propagules/g soil. Colonies of FP on dilution plates were typically larger on M3SB than on M3SR. Axenic colony growth rate of FP was greatly reduced on M10SR compared to MR, and recovery from artificially infested soil at 10^{-3} dilution on MR was double that on M10SR. Recovery of FP from naturally in-fested soil at 10⁻¹ dilution was less on M10SR than on M3SR.

SUGAR EXUDATION FROM DEVELOPING AXENIC PEANUT FRUITS. M.G. Hale and F.J. Shay, Dept. of Plant Pathology and Physiology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

Axenic peanuts were allowed to grow in special containers constructed so that the rooting medium and the pegging medium were in separate containers. Growing conditions were controlled in isolator chambers in a growth room at 25-30°C and continuous fluorescent illumination at about 1200 fc. Pegs and fruits developed in Weblite. At termination of the experiments, pegs and fruits were carefully removed from the Weblite in the pegging chamber, counted and stage of develop-ment recorded. Weblite was extracted with 3, 300 ml portions of CO_2 free $Ba(OH)_2$, the extracts pooled, neutralized with H_2SO_4 and evaporated to dryness. The dried residue was extracted with 10 ml pyridine, the volume reduced $\underline{\text{in}}$ $\underline{\text{vacuuo}}$ under reduced pressure and methyl silyl derivatives made. Qualitative and quantitative measurements were made using gas-liquid chromatography. Results were expressed as µg each sugar exuded per plant per week. With one or two exceptions, sugars found were the same as those in root exudates previously reported. (Aided by Cooperative Agreement 12-14-100-9711 with USDA, ARS, Plant Science Div.).

RELATIVE CONTENTS OF P, K, Ca, Mg, B, Mn, Zn, AND Cu IN 15 PEANUT CULTIVARS. <u>D. L. Hallock</u>, D. C. Martens, and M. W. Alexander. Tidewater Research Station, Va. Poly-

technic Inst. and State Univ., Holland, Va. 23391
The main stem leafy tops of 15 peanut cultivars representing four peanut market types were sampled at two stages of development in 1968 and 1969 and analyzed for contents of 8 nutrients. Nutrient content ranges in samples taken at full bloom stage in 1968 and 1969, respectively, were 0.29-0.31 and 0.20-0.26% P; 3.15-3.38 and 2.96-3.60% K; 0.92-1.10 and 1.49-2.10% Ca; 0.43-0.50 and 0.50-0.66% Mg; 23-29 and 69-102 ppm B; 47-82 and 25-41 ppm Mn; 43-53 and 28-37 ppm Zn; and 2.9-6.7 ppm Cu in 1969. Similarly, the ranges for samples taken near mature stage in 1968 and 1969, respectively, were 0.12-0.16 and 0.19-0.23% P; 1.80-2.33 and 2.34-3.20% K; 1.41-2.13 and 2.00-2.98% Ca; 0.41-0.60 and 0.41-0.65% Mg; 23-41 and 46-60 ppm B; 34-77 and 28-59 ppm Mn; 23-41 and 36-63 ppm Zn; and 4.2-9.1 ppm Cu in 1969.

Contents of P, K and B were highest in the full bloom stage samples and Ca and Cu in the mature stage samples. Contents of Mg, Mn and Zn were similar at both stages.

The large and small seeded Virginia types averaged higher in Ca, Mg, B, Mn and Zn than the Spanish and Valencia types. Cu contents were lower in the large seeded Virginia type and P contents were similar in all types.

EFFECTS OF CITRININ ON GROWTH OF GERM-FREE MARIGOLD PLANTS. K. M. Hameed*. Dept. of Plant Pathology and Physiology, Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061

Germ-free marigold plants (Tagetes erecta L.) were grown inside flexible plastic Isolators, under 1800 foot candle light at 25-30°C. Coarse sand and 50% Hoagland-Arnon nutrient solution (plus Fe-EDTA solution 5 ml/1) served as rooting medium. Plants were treated with 0.1, 1.0 and 10 ppm citrinin (4,6-Dihydro-8-hydroxy-3,4,5trimethy1-6-oxo-3H-benzopyran-7-carboxylic acid), a metabolite of Penicillium citrinum Thom., dissolved in citrate buffer (pH 7.5) and added into the rooting medium. Treated plants showed higher values for plant heights; 43, 40, 37 cm, fresh weights; 82, 62, 60 g and dry weights; 13, 9.8, 9.5 g than the control measurements of 30 cm, 45 g, and 6.8 g respectively. Percent protein in plants treated with 1.0 ppm citrinin (22.3) was significantly higher than the 10 ppm (19.1). The control plants, 0.1 and 10 ppm citrinin treated plants revealed comparable percent protein values, 20.5%, 21.0% and 19.1% respectively. The results of these studies, then, indicated an initial stimulation of growth of germ-free marigold plants at 0.1 and 1.0 ppm citrinin, with no effect at the 10 ppm level.

EFFECT OF PICLORAM ON THE GROWTH OF FIVE SOIL FUNGI. K. M. Hameed*, and C. L. Foy. Dept. of Plant Pathology and Physiology, Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061

Five different soil fungi--Trichoderma viride, Fusarium oxysporum, Helminthosporium victoriae, Penicillium lanosum and Aspergillus flavus-- were grown in modified soil extract medium containing 1, 10, 100 and 1000 ppm picloram (technical, acid and formulated, Tordon 22K) or 10 and 100 ppm glucose (on a carbon equivalent basis). All fungi grew measurably (mycelium, dry weight) under all treatments. All five fungi failed to produce mycelial pads in a synthetic liquid medium lacking carbon or nitrogen but supplemented with picloram.

APPLE MILDEW CONTROL WITH LOW VOLUME SPRAYS. K. D. Hickey*.

Dept. of P.Path. and Phys., VPI & SU, Winchester, Va. 22601.

Control of apple powdery mildew, caused by <u>Podosphaera</u> leucotricha (E. and E.) Salm., was obtained in field tests where fungicide mixtures were applied with two types of airblast sprayers (conventional and mist) at from 11 to 109 gallons per acre (gpa). The level of control was directly related to the amount of fungicide used per acre. Fungicide rate had a greater effect on control than the amount of water per acre or the type of airblast sprayer used. Mildew control was obtained in the lower part of trees (3-8 ft.) with Dikar 80W at 6.6 lb/A. when applied with either sprayer in varying amounts of water per acre at 2.0 and 3.0 mph. Disease severity varied from the bottom to the top of the tree depending on the sprayer ground speed, type of sprayer and the amount of fungicide used. Control was significantly reduced on trees sprayed with Dikar 80W 4.4 1b/A. (33% reduction) applied in 11 gpa at 3.0 mph with the mist sprayer. Control was comparable on the lower part of trees sprayed with the conventional sprayer at 3.0 mph using standard (6.6 lb.) and reduced (4.4 lb.) rates of Dikar. Control was significantly less near the top of the trees (15-20 ft.) with treatments containing the same amount of fungicide applied with this sprayer in less than 27 gpa. The data obtained showed that the level of mildew control appeared to depend on adequate deposits of effective fungicide mixtures properly timed to protect the leaves as they develop and not upon the degree of leaf wetting with the spray mixture.

THE COLORADO POTATO BEETLE PROBLEM IN SOUTHEASTERN VIRGINIA. R. N. Hofmaster. Dept. of Entomology, Va. Truck and Ornamentals Res. Station, Painter, Va. 23420.

The Colorado potato beetle has become an increasingly acute problem on the Eastern Shore of Virginia. Resistance to DDT was observed in 1953, to dieldrin in 1958 and since then to most chlorinated hydrocarbons and many phosphates. At the present time adequate control of this pest is the limiting factor in Irish potato production in southeastern Va. Promising results have been obtained with 25-30 lbs. of 10% phorate (Thimet) granules/ $\mbox{$\Lambda$}$. placed in the fertilizer bands at planting. Unfortunately, this treatment does not last the entire season and problems have been encountered with potato beatle build-up three to four weeks before harvest. Investigations with over 50 systemic insecticides have shown two of these, aldicarb (Temik) and carbofuran (Furadan), to be somewhat more effective than phorate in that they show greater initial activity and are more persistent. Phorate and carbofuran have also given excellent performances when combined with liquid fertilizers.

Foliage sprays of azinphosmethyl (Guthion) or carbaryl (Sevin) are widely used and, while still effective, simply fall short in residual action. Extensive screening trials, in which approximately 50 compounds are field tested annually, have conclusively demonstrated that carbofuran at 0.5 lb. actual/A. holds most promise of extended protection.

PROGRESS AND PROBLEMS IN CATFISH CULTURE IN VIRGINIA. D. W. Holmes* and K. B. Cumming. VPI&SU Div. For. and Wildl. Sci. Coop. Fish Unit, U.S.D.I., Blacksburg, Va., 24061

The commercial production of channel catfish, <u>Ictalurus</u> <u>punctatus</u>, was researched in Virginia in 1970. Four ponds in various counties were stocked with fingerlings in November 1969 at 2500 per acre. Later, in June 1970, catfish were also placed in cages in the three ponds to test the effectiveness of cage culture; the stocking rate was 500 per cage. In the two southern Virginia ponds, the fish were fed for approximately 140 days while the fish in western Virginia pondwere fed for only 83 days. All fish were fed on Purina floating catfish ration ad lib., 6 days per week. Dalton's pond and Farmer's pond in southern Virginia had 75.5% and 82.6% survival of fish respectively at the end of the growing season while Hoge pond in western Virginia had a 75% survival rate. The harvest success was estimated to be approximately 95% of all fish present in the three ponds. The average fish weights attained in Dalton's, Farmer's and Hoge's ponds were 13.2, 11.8 and 5.6 ounces, respectively. Feed conversion rates attained were 1.76:1 in Dalton's pond, 1.77:1 in Farmer's pond and 1.41:1 in Hoge's pond. Total fish production was 2148.5 pounds in Dalton's pond, 2902 pounds in Farmer's pond and 1029 pounds in Hoge's pond. Cat-fish farming seems feasible in the piedmont area of Virginia but was unsuccessful in the montaine region on a single growing season basis. (Aided by OEO grant 303332-1)

ABSORPTION AND TRANSLOCATION OF 2-(3,4-DICHLOROPHENYL)-4-METHYL-1,2,4-OXADIAZOLIDINE-3,5-DIONE IN GOSSYPIUM HIRSUTUM L. D. W. Jones* and C. L. Foy. Dept. Plant Path. & Physiol., Va. Poly Inst. & State Univ. Blacksburg. Va. 2061

Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061
Absorption and translocation of the ¹⁴C-labeled herbicide
(VCS 438) and its metabolites in cotton were studied using
autoradiography and counting. Absorption into roots of 30day plants via nutrient solution was rapid; translocation
into stem and leaves occurred 12 to 24 hr after treatment.
Older (40-day) plants translocated ¹⁴C more rapidly. Translocation of ¹⁴C-labeled compounds correlated well with transpiration, indicating movement in the xylem. Radioactivity
in leaves of root-treated plants was first located in the
veins, then distributed throughout. Little ¹⁴C moved into
young growing points: most accumulated in older leaves.

young growing points; most accumulated in older leaves.
Foliar penetration of 14C occurred rapidly in primary leaves treated with a 20 µl droplet of VCS-438-14C dissolved in acetone-1% Tween 80 (1:1). Acropetal translocation of 14C-labeled compound out of the treated area began within 3 hr and increased with time through 6 days. No basipetal movement was detected after 6 days of treatment. As in the root absorption studies, 14C movement first occurred in the leaf veins, then more generally in interveinal tissues distally from the point of application. The translocation pattern of VCS-438 or its metabolites was characteristic of compounds which move only in the apoplast, the non-living cell wall continuum that surrounds and contains the living symplast.

AVAILABILITY OF IRON IN DEFLUORINATED PHOSPHATE FOR GROWING PIGS. E. T. Kornegay. Dept. of Animal Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Thirty-six pigs (avg. body weight 6 (4 kg) degree as iver

Thirty-six pigs (avg. body weight, 6.4 kg) denied an iron injection and weaned at three weeks of age were used to evaluate the availability of the iron (Fe) in defluorinated phosphate (DFP) relative to the Fe in ferrous sulfate (FS). The following semi-purified diets were fed: 1) basal - 20 ppm total Fe; 2) plus FS - 71 ppm total Fe; 3) plus FS - 97 ppm total Fe; 4) plus DFP - 78 ppm total Fe; 5) plus DFP - 103 ppm total Fe; 6) plus DFP - 125 ppm total Fe. The trial lasted for 7 weeks. Pigs were fed each diet as close to full feed as possible without excessive wastage. Pigs fed diets containing 71 and 97 ppm Fe from FS and 103 and 125 ppm Fe from DFP had similar body weights indicating that these levels of Fe were adequate for maximum growth. The pigs fed the basal diet (20 ppm Fe) had the lowest body weights, with pigs fed the lowest level of DFP (78 ppm Fe) having intermediate body weights. The highest values for hemoglobin and hematocrit were obtained from pigs fed diets containing 97 ppm Fe from FS, followed closely by values from pigs fed diets containing 71 ppm Fe from FS and 103 and 125 ppm Fe from DFP. Pigs fed the basal diet (20 ppm Fe) were unable to maintain their hemoglobin and hematocrit values were intermediate for pigs fed the diet with 78 ppm Fe from DFP. The relative availability of Fe in DFP was 85, 73 and 67%, respectively, for body weight, hemoglobin and hematocrit values.

FACTORS RESPONSIBLE FOR INCREASED YIELD OF SOYBEANS GROWN UNDER IRRIGATION. J. A. Lutz, Jr., and \underline{G} . \underline{D} . Jones, Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The irrigation of soybeans in a fertility experiment on Davidson clay loam soil in 1970 significantly increased the yield of beans and plant growth. Factors responsible for the increase were increased stem length, development of larger seeds, increased number of seeds per plant, and increased weight of seeds per plant.

Irrigation increased bean yields 75%, total plant yields 61%, seed size 38%, number of seed per plant 54%, and the

weight of seed per plant 110%.

Irrigation water was applied during the podding period because soil moisture was too low for normal plant growth. The soil moisture in the 0-12" soil depth dropped to 20% on August 14 and September 3, thus indicating that 50% of the available soil water had been depleted. Irrigation was based on a 50% depletion of available soil moisture in the 0-12" soil depth.

SURVIVAL OF MELOIDOGYNE ARENARIA IN ROOTS, STEMS, AND FRUIT OF ARACHIS HYPOGAEA AFTER HARVEST. L. I. Miller. Dept. of Plant Path. & Phys., V.P.I. & S.U., Blacksburg, Va. 24061

Peanut plants heavily infested with viable eggs of the peanut root-knot nematode were harvested the last week of October. The harvested plants were either dried artifically or in the field in a shock. The fruit of the artifically dried plants (not to exceed 100°F) had reached a moisture content of 8% (d.b.) one week after harvest and eggs from galled root, stem, fruit, and from the soil adhering to the plant parts were not viable. Eggs from the plant parts of the drying plants in the shock and from the soil adhering to them were viable one week after harvest, but were not viable one month after harvest when the fruit contained 8% moisture. It is concluded that the peanut root-knot nematode is rarely disseminated in the movement of saleable peanut fruit and hay.

PECTIC SUBSTANCES AND NON-STRUCTURAL CARBOHYDRATES IN HEALTHY AND BLACK SHANK DISEASED TOBACCO STEMS. L. D. Moore, Dept. of Plant Pathology and Physiology, Va. Polytech. Inst. and State Univ., Blacksburg, Virginia 24061

Stems of Nicotiana tabacum 'Virginia Gold', colonized by

Stems of Nicotiana tabacum 'Virginia Gold', colonized by Phytophthora parasitica var. nicotianae were analyzed for extractable pectic substances and hot water soluble carbohydrates. All data was expressed as $\mu g/mg$ dry weight of tissue. Healthy stems contained 170 to 205 μg pectic substances as identified by the carbazole test. Diseased stems contained 90 to 100 μg pectic substances. When stems were extracted successively with water, HCl and NaOH there were 50 to 60% less HCl extractable pectic substances in diseased tissue than in healthy tissue. Pectic substances extractable with water or NaOH were present in nearly identical quantities in diseased and healthy tissues.

The water extracts were analyzed for non-structural carbohydrates and reducing sugars using the anthrone and Somogyi-Nelson tests, respectively. Healthy tissue contained 170 to 230 µg total carbohydrates and 75 to 100 µg reducing sugars. Diseased tissues analyzed 2, 4 and 8 days after inoculation contained 110, 93 and 54 µg total carbohydrates and 72, 53 and 31 µg reducing sugars, respectively.

These results suggest that pectic substances and non-

These results suggest that pectic substances and nonstructural carbohydrates are attacked and utilized by <u>Phytophthora parasitica</u> var. <u>nicotianae</u> during colonization of tobacco stems. EFFECT OF LEVEL AND FORM OF NITROGEN ON MAGNESIUM UTILIZATION. W. F. Moore*, J. P. Fontenot and K. E. Webb, Jr.* Dept. of Animal Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Twelve wether lambs were used in two 20-day metabolism trials to study the relative effects of two levels of crude protein (nitrogen) and two levels of non-protein nitrogen (urea) on magnesium utilization in lambs. Each trial consisted of four successive 5-day collection periods. The experimental design was a 2X2 factorial with two levels of crude protein and two levels of non-protein nitrogen. The two crude protein levels were approximately 10 and 32%, and at each protein level, 0 and 35% of the crude protein was provided by urea. Rumen ammonia-N levels were higher for the animals consuming the high-protein rations. There were no significant differences in apparent magnesium absorption among the four treatments. Magnesium retention was greater (P<.01) for the animals consuming the low-protein rations during all periods and there were no significant differences due to form of nitrogen. Blood serum magnesium levels were similar for the animals fed all four rations.

DEVELOPMENT OF A DEVICE TO MEASURE CHANGES IN FLIGHT PATTERNS OF TETHERED MOTHS. J. V. Perumpral*, U. F. Earp, Virginia Polytechnic Institute and State University and J. M. Stanley, Ag. Engr. Res. Div., ARS, USDA, Blacksburg, Virginia 24061.

Ā new technique was developed to obtain oscillographic recording of the wingbeat of a moth in stationary flight. The operating principle and construction details are discussed. The device developed was found to be capable of detecting any change in wingbeat frequency and wingbeat amplitude. Response to 80 dB ultrasonic energy of 40 kHz was studied by conducting a series of tests using moths grouped according to age and sex. Recordings indicating the change in flight pattern are shown and discussed.

EVIDENCE OF AN UNIDENTIFIED GROWTH FACTOR FOR TURKEYS IN COMMERCIAL STREPTOMYCES RESIDUES AND ITS INTERACTION WITH ANTIBIOTICS. <u>L. M. Potter</u>. Dept. of Poultry Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061 Streptomyces fermentation residues from the manufacture of

antibiotics were added to diets of turkeys to determine their effects on body weights, feed consumptions and feed efficiencies. In two experiments, the average body weights of turkeys at eight weeks of age were increased 10.1% by the addition of 0.25% Fermacto-500, 8.1% by the addition of 22 ppm erythromycin thiocyanate, and 8.1% by the addition of both supplements. In another experiment, the average body weights of turkeys at eight weeks of age were increased 10.9% by the addition of 0.625% liquid streptomyces solubles, 8.6% by the addition of 35 ppm erythromycin thiocyanate, and 8.4% by the addition of both factors. In two other experiments, the average eight-week body weights were increased 4.6% from the addition of 0.25% dry or 0.50% wet streptomyces and bacillus fermentation residue, 4.9% from the addition of 17.1 ppm bacitracin, and 4.1% from the addition of both supplements. From these data, an unidentified growth factor is postulated to be present in these streptomyces fermentation residues, and this factor is postulated to be either a metabolite produced by microorganisms of the intestinal tract of turkeys fed antibiotic containing diets or another previously undetected antibiotic.

CHANGES IN PROTEIN CONTENT OF TOBACCO STEMS AFTER HEAT TREATMENT AND SUBSEQUENT INOCULATION OF ROOTS WITH ** PHYTOPHTHORA PARASITICA VAR. NICOTIANA. G. E. Sanden and L. D. Moore. Dept. of Plant Pathology and Physiology, V.P.I. & S.U., Blacksburg, Virginia 24061

Roots of intact plants of a resistant cultivar of flue cured tobacco, Nicotiana tabacum 'Coker 187', were subjected to the following treatments: (i) roots heated by immersion in a water bath at 50 C for one minute and inoculated; (ii) roots inoculated only; (iii) untreated controls. Stunting and limited stem lesion development were observed for treatment (1), while plants of treatment (ii) exhibited only stunting. Stem tissue was assayed 10 days after treatment for total protein content by the Lowry method. Tissue extracts from stems of inoculated only (ii), and heated and inoculated plants (i) contained 9.2 mg protein and 9.5 mg protein/g dry weight of tissue, respectively. Tissue extracts from the untreated control (iii) contained only 7.6 mg protein/g dry weight. Although colonization of this resistant cultivar was limited, it is apparent that protein metabolism of the noninfected stem was influenced by the pathogen.

INFLUENCE OF FOUR AQUATIC SPECIES ON DICHLOBENIL RESIDUE IN WATER. R. W. Schumacher and S. W. Bingham. Dept. of Plant Path. & Physiol., V.P.I. & S.U., Blacksburg, Va. 24061

Two emersed species, parrotfeather and water hyacinth, and two submersed species, elodea and Eurasian milfoil were utilized in this study. Dichlobenil concentrations used were 0 μ g/ml, 0.17 μ g/ml and 1.7 μ g/ml. Plant and water samples were taken at various time intervals and extracted with benzene to determine the amount of chemical remaining. Dichlobenil was measured with a gas chromatograph equipped with an electron-capture detector. A 6-foot by 1/4-inch glass column packed with 1.5% OV-17 and 1.95% OF-1 on 80/100 Gas chromasorb Q and maintained at 150 C was utilized. Dichlobenil detection limit was 0.01 ng.

The emersed species provided a higher rate of removal than did the submersed species. Water hyacinth removed over 30% of the herbicide in four days. Removal by parrotfeather was greatest during the first 24 hr followed by a decline. Dichlobenil was found to be quite volatile from the water. The amount of herbicide detected in the plant tissue was low, indicating that metabolism and/or volatilization from the foliage was quite rapid.

The reduced rate of removal with time may be due in part to herbicidal injury. Both plant growth and transpiration were reduced in the treated plants. At the higher rate, shoot tips were severely injured. Supported by Department of the Interior, Project No. A-003-Va.

GAS-LIQUID CHROMATOGRAPHY OF SUGARS IN EXUDATES OF AXENIC PEANUT ROOTS. F. J. Shay, R. W. Young, and M. G. Hale. Dept. of Plant Path. and Physiol., Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061

Weekly collections of nutrient solutions used in axenic growth of peanut plants were freeze concentrated and freeze dried. The residue was dissolved in 10 ml of pyridine and centrifuged. The supernatent containing dissolved organic root exudates was evaporated to dryness, and redissolved in 1.0 ml of pyridine. Methylsilyl derivatives of sugars in the root exudate were prepared by adding 0.9 ml of hexamethyldisilazane plus 0.1 ml of trifloroacetic acid and kept at room temperature 24 hours. Standards were prepared in the same manner as exudate samples. G-C analysis was accomplished on a 6 ft x 1/4 in (OD) glass column containing 3% OV-3 on 80 to 100 mesh chromosorb WHP, with a linear temperature program of 5C/min from 120 to 220C with a four minute program delay. Detector and injection port temperatures were 265 and 270C respectively. The flow of carrier gas, nitrogen was 40 ml/min. Individual sugars as little as 0.1 µg could be identified and quantitated. A total of sixteen sugars in peanut root exudates was identified and quantitated by this technique. (Aided by Cooperative Agreement 12-14-100-9711 with USDA, ARS, Plant Science Div.).

THE EFFECT OF BROMACIL ON PERENNIAL GRASSES. J. W. Shriver* and S. W. Bingham. Dept. of Plant Pathology and Physiology, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

Bromacil, a substitute uracil herbicide, has exhibited marginal selectivity in controlling tall fescue and orchard-grass in Kentucky Bluegrass turf. Postemergence applications up to 1 lb/A (1.12 kg/ha) were made during the summer and fall of 1970 on established plugs. The growth status of the plants was monitored during the summer and fall of 1970 and into the spring of 1971 using visual injury ratings, clipping dry weight, percent carbohydrates, and photosynthesis rate

Bromacil, a known photosynthetic inhibitor, decreased the clipping dry weight and % carbohydrates more in tall fescue and orchardgrass than in Kentucky Bluegrass during the summer and fall of 1970. CO₂ absorption as a measure of photosynthesis was measured using an infra-red CO₂ gas analyzer. CO₂ uptake was reduced more in tall fescue and orchardgrass than in Kentucky Bluegrass. Visual ratings during summer and fall indicated that tolerance of the three species was as follows: Kentucky Bluegrass>Tall Fescue>Orchardgrass. Winter survival of plugs in April 1971 indicated that orchardgrass and tall fescue were susceptible to winter kill with Kentucky Bluegrass appearing normal with 1 lb/A bromacil treatment.

MEXICAN BEAN BEETLE CONTROL ON SOYBEANS IN TIDEWATER VIRGINIA. J. C. Smith. Tidewater Res. Sta., Va. Polytechnic Inst., Holland, Va. 23391.

Adults and larvae of the Mexican bean beetle, Epilachna varivestis Mulsant, were responsible for foliage loss on commercial varieties of soybeans that caused economic losses in 1967, 1968, and 1970. Value increases per acre from control averaged \$4.25, \$26.50, and \$20.75 in 1967, 1968 and 1970, respectively. Plots treated with soil-applied systemic insecticides produced higher yields than plots treated with single applications of foliar sprays. Layby applications of systemic insecticides produced higher yields than in-furrow applications. Only carbofuran was systemically effective for bean beetle control when applied in-the-furrow. Layby applications of carbofuran at 2.0 lb AT/acre and disulfoton at 1.0 AI/acre produced the highest yield on plots in 1968. These treatments increased value per acre by \$39.00. In 1970, Mexican bean beetles were reduced from an average of 33.3 per 10 sweeps on untreated controls to 11.2 by in-furrow carbofuran treatments. Yields were significantly increased by 5.1 bu/acre. As layby treatments, carbofuran and aldicarb @ 2.0 lb AI/acre and Fisons 6897 @ 3.0 lb AI/acre effectively controlled bean beetles and produced significant increases in yield. Only carbofuran significantly increased seed size. All candidate foliar sprays in 1970 significantly reduced Mexican bean beetles. Yield increases from the spray treatments ranged from 4.7 bu/acre for the least effective to 10.1 bu per acre for the most effective spray.

CULTIVATION VS. NO CULTIVATION OF SOYBEANS. <u>T. J. Smith</u>, and H. M. Camper, Jr.* Agronomy Dept., Va. Poly. Inst. and State Univ., Blacksburg, Va. 24061.

The development of chemicals for weed control in cultivated crops may eliminate the need for tilling of the soil which has been the convential method used in controlling weeds. This experiment was conducted for four years at two locations using three soybean varieties to determine effects of cultivation per se on soybeans when weeds were controlled with a pre-planting application of a herbicide. Two cultivations at approximately four and six weeks after seeding significantly increased seed yields for the four-year average from 1.6 to 2.4 bushels per acre for different varieties; and reduced plant height for each variety on Sassafras sandy loam soil at Warsaw. Cultivation decreased seed size but had no consistent effect upon plant lodging or maturity. One cultivation, only, on Cecil sandy loam soil at Charlotte Court House did not affect average seed yield, time of maturity or plant lodging over the four-year period. Cultivation produced taller plants and a slight reduction in seed size.

COMPARISON OF A NEMATICIDE AND RESISTANT TOBACCO VARIETY FOR THE CONTROL OF THE UNDESCRIBED OSBORNE'S CYST NEMATODE. L. Spasoff*, J. A. Fox*, and P. B. Cassell*, Department of Plant Pathology and Physiology, VPI & SU, Blacksburg, Virginia 24061

The effectiveness of the nematicide $\operatorname{Mocap}^{\hbox{\scriptsize $I\!\!\!\!R$}}$ and a resistant variety of tobacco (BVa523) for control of the Osborne's cyst nematode (OCN) was measured by the growth response of a susceptible tobacco variety (NC95), planted in plots treated in 1969 as follows: 1) BVa523 and Mocap, 2) BVa523, 3) NC95 and Mocap, 4) NC95 and Mocap in 1969 and 1970. Mocap (50 lbs/A) in 10% granular form was applied 6 inches deep in 24 inch bands to rows spaced four feet apart. Population densities of OCN in the plots were determined in 1969 and 1970 before Mocap was applied and tobacco trans-planted. The average fresh weights of susceptible plants in each treatment were: 1) 1736, 2) 1247, 3) 1189, 4) 694, and 5) 1377 grams, respectively. The nematode populations decreased only on plots planted with the resistant variety, with and without Mocap treatment. The reduction of OCN populations by the resistant variety in 1969 gave a level of control of OCN in 1970, as measured by plant weights of susceptible variety, equal to that obtained with application of Mocap.

EXPANDED SHALE-SOIL MIXTURES FOR CULTURING THE UNDESCRIBED OSBORNE'S CYST NEMATODE ON TOBACCO. L. Spasoff* and L. I. Miller. Dept. of Plant Path. & Phys., V.P.I. & S.U., Blacksburg, Virginia 24061

It has been determined empirically that more females and cysts of the Osborne's cyst nematode (OCN) were produced on N.C. 95 variety tobacco when an expanded shale (W, horticultural grade Weblite) was added to Groseclose silt loam soil (S). The following W:S mixtures (v/v) were evaluated in order to determine the best potting medium for culturing large numbers of cysts for inoculum: 0:1, 1:1, 2:1, 3:1, and 1:0. Twenty thousand eggs and/or larvae of the OCN were introduced in 15-cm pots. A single 2-months old N.C. 95 tobacco seedling was transplanted to each pot and grown at air temperatures of $24\text{-}29^{\circ}\text{C}$. Each treatment was replicated two times. After eight weeks, the soil in each pot was screened and the average number of females and cysts/ pot for the various mixtures were: 0:1-189, 1:1-320, 2:1-839, 3:1-499, 1:0-55 Significantly greater number of females and cysts were produced in the 1:1 and 3:1 mixtures than in the 0:1 and 1:0 mixtures, but the maximum number produced was in the 2:1 W:S mixture. The plants were fertilized and watered uniformly to obtain good growth and there was no significant difference in root and foliar growth of plants in the different mixtures. The balance of available water and aeration probably was more nearly optimum for egg hatch and larval penetration of roots in the 2:1 W:S mixture than in the other mixtures tested.

TOBACCO HORNWORM MOTH SENSITIVITY TO UV AND VISIBLE RADIATION OUTDOORS <u>J. M. Stanley</u> and U. F. Earp. Agricultural Engineering Res. Div., ARS-USDA and Agricultural Engineering Dept., VPI&SU, Blacksburg, Va. 24061

A study was conducted to determine if electrophysiological evaluations of insect sensitivity to radiation could be made outdoors. If so, the distances that tobacco hornworm moths, Manduca sexta (Linnaeus), could detect the radiation from lamps as used in traps would be of interest in determining the effectiveness of electric trapping devices.

Individual laboratory reared moths approximately 36-hours old and unmated were placed on a stereotactic stage. Stainless steel electrodes were positioned in the eyes to a depth of $500-750\mu$, by means of micromanipulators. By means of a shutter mechanism radiation from lamps was permitted to strike the "irradiated" eye while the "non-irradiated" eye was covered with a black lacquer and oriented away from the radiation.

Signals were obtained at all distances when lamps were placed from 50 to about 600 ft. from the insect. Nerve potentials of 2.2 and 1.4 mv. at 50 ft. decreasing to 0.3 and 0.1 mv. at 450 ft. were obtained from male and female moths respectively, when using a 15-watt blacklight fluorescent lamp. At 600 ft. the sensitivity was primarily an "on-off" signal. Differences in sensitivity were obtained when using other energy sources, some in the visible spectrum.

A PIN OAK BLIGHT ASSOCIATED WITH A SPECIES OF ENDOTHIA.

R. J. Stipes, P. M. Phipps* and O. K. Miller, Jr. Depts. of Plant Pathology and Physiology and Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

We observed and initiated investigations on a canker disease of pin oak (Quercus palustris) found at Hampton, Virginia in September, 1970. The disease, which occurred on large and small branches, was widespread in one street planting. Dieback, premature defoliation and a general decline were observed, while leaves on affected branches exhibited scorch symptoms. The perennial canker lesions were discrete, sunken, elongate and bordered by calloused folds. Bright orange to dark brown fruiting bodies present were constituted of predominantly solitary, pulvinate stromata. Within were found labyrinthiform, pycnidial cavities yielding bacilloid conidia. The conidial stage appears to be a species of Endothiella Sacc., and resembles the imperfect stage of Endothia gyrosa. No mature perithecia have been observed to date. We believe that the associated fungus is a species of Endothia, possibly E. gyrosa.

 $\underline{\text{IN VITRO}}$ DIGESTION OF ORCHARDGRASS STRAINS FROM FIVE LOCATIONS IN VIRGINIA. $\underline{\text{L. H. Taylor}}.$ Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Orchardgrass, <u>Dactylis glomerata</u> L., has been reported to differ in digestibility of forage dry matter when sampled at different stages of growth. Different strains and varieties also have been reported to vary in digestibility. This study investigated digestibility of strains grown at several locations when sampled at the same stage of growth during one growing season.

Trials having the same fifteen orchardgrass strains as entries were sampled at Blacksburg, Charlotte Court House, Middleburg, Orange and Warsaw, Va. in the spring of 1970. Samples were complete stems cut two inches from the ground surface when the panicle had partially emerged from the upper leaf. In vitro digestibility of dry matter was determined using the two-stage technique of Tilley and Terry. Location had little effect on the dry matter digestibility of the orchardgrass forage. The overall digestibility of strains sampled at the same stage did not differ significantly.

EVALUATION OF BACTERIAL AND YEAST PREPARATIONS FOR GROWING PIGS. <u>H. R. Thomas</u> and E. T. Kornegay. Va. Polytechnic Inst. and State Univ., Holland and Blacksburg, Va.

Two replicated trials were conducted using five rations in each trial with a total of 36 pigs assigned randomly to each ration. An 18 percent crude protein basal ration consisting of corn and soybean meal, fortified with vitamins and mineral was fed ad libitum. Rations fed were: 1) Basal, 2) Basal plus Antibiotic (chlortetracycline-penicillinsulfamethazine), 3) Basal plus Alfa-Zyme, 4) Basal plus Lacto-Plus, 5) Basal plus Vigortone #3. Alfa-Zyme, Lacto-Plus and Vigortone #3 are commercially prepared bacterial and yeast products and are recommended for use in the young pig diet for preventing post-weaning stress. Rations were mixed as directed by the manufacturer.

In trial 1 there were no significant differences in the various performance criteria with the exception of average daily gain in replication I. Average daily gain made by pigs fed ration 2 was significantly faster than that made by pigs fed ration 3, but was not significantly different from the gains made by the pigs fed ration 1, 4 and 5. In trial 2 there were no significant differences in the various performance criteria. Diarrhea was observed in all pigs irrespective of ration in trial 1, however diarrhea was not observed in trial 2.

EFFECT OF FEEDING DIFFERENT LEVELS OF BROILER LITTER ON PERFORMANCE AND HEALTH OF EWES AND THEIR LAMBS. K. E. Webb, Jr.*, J. P. Fontenot, R. J. Buehler* and K. G. Libke, Dept. of Animal Science, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Broiler litter was fed to 32 yearling ewes to determine its effect on performance and health of ewes and their lambs. Isocaloric rations containing 0, 25 and 50% wood shaving broiler litter sterilized by dry heat at 150 C for 4 hr. were fed. The experiment was initiated 6 wk. prior to lambing with the ewes and lambs kept on wire mesh floors. Lamb daily gain, carcass grade and backfat thickness were not significantly affected by litter level. Until 137 days after the ewes had been on the experimental rations no abnormalities were observed. At that time one ewe in the lot fed 50% litter died from copper toxicity. At the end of 254 days death from copper toxicity had resulted in 64% of the ewes fed the ration containing 50% litter and 55% of those fed 25% litter. Mean liver copper levels, dry basis, at death or slaughter for the lots fed 0, 25 and 50% litter were 648, 1993 and 2671 ppm for the ewes (P<.01) and 572, 891 and 961 ppm for the lambs, respectively. Copper content of the litter averaged 195 ppm resulting from feeding copper sulfate to the chicks. No treatment-related abnormalities other than copper toxicity were evident from blood and urine analyses, gross observations, detailed necropsies and studies of histological sections.

PARASITISM OF 'TIFGREEN' BERMUDAGRASS AND REED CANARY GRASS BY ROOT-KNOT NEMATODES.

Dept. of Plant Pathology A. J. Webber, Jr.*, and J. A. Fox*.

Dept. of Plant Pathology and Physiology, Va. Polytechnic

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Parasitism of Cynodon sp. (c. v. 'Tifgreen' bermudagrass = BC), Phalaris arundinacea (c. v. Reed canary grass = CG), and Lycopersicon esculentum (c. v. Bonny Best tomato = T) by four root-knot nematodes (Meloidogyne spp.) was studied at 26 and 32°C soil temperature. Initial infection by larvae and adult development on BG and CG by M. incognita was numerically comparable to that on T but differentiation of larvae as males on BG and CG was ten to twenty and four to five times greater, respectively, than that on T. Infection of T by $\underline{\text{M}}$, $\underline{\text{javanica}}$ was twice as great as that of BG and CG, but adult development on BG was numerically comparable to that on T while adult development on CG occurred only at 32°C and at a level one-third that on T. Differentiation of M. javanica larvae as males on BG and CG, and on T at 32°C, was twenty to forty times greater than that on T at 26°C. Infection and adult development on T by $\underline{\text{M}}$. arenaria was twice as great as that on BG and six times greater than that on CG. Differentiation of \underline{M} . arenaria larvae as males on BG, and on T at 32°C, was nine to fourteen times greater than that on T at 26°C. Meloidogyne graminis did not infect T, but infection and adult development on BG was five times greater than that on CG while differentiation of larvae as males on CG was three to four times greater than that on BG at $32\,^{\circ}\text{C}$.

AN INEXPENSIVE CONTROLLED TEMPERATURE TANK FOR PLANT CULTURE STUDIES. A. J. Webber, Jr.*, J. A. Fox*, and M. G. Hale. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A controlled temperature tank for plant culture studies was designed and fabricated from materials costing less than \$10.00. The basic tank unit consisted of a rectangular styrofoam picnic basket without a handle. Sheets of styrofoam 2 cm thick were cut to a size slightly smaller than the inner dimensions at the top of the basket. Holes slightly larger than the diameter of receptacles used for plant material were cut through the styrofoam sheets and a 100 watt aquarium heater fitted through a hole of appropriate size in the center. Aluminum paint was applied to each basket and styrofoam insert. The styrofoam insert was then fitted into a basket, the basket filled with water of the desired temperature, and the heating unit adjusted to maintain the desired temperature. Such tanks were maintained at constant temperatures as little as $2^{\circ}C$ above ambient with an accuracy of $\pm~1C^{\circ}$ in both the greenhouse and airconditioned laboratory. Series of tanks at different temperatures have been used to provide constant soil temperatures for seedlings and small plants grown in beakers and centrifuge tubes during nematode studies. The tanks have also been used to provide two or three different soil temperatures above a constant air temperature in the growth chamber.

Section of Astronomy, Mathematics, and Physics

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MAGNETIC DENSIMETER USING AN R.F. SENSING COIL. S. P. Almeida and $\frac{T.~H.~Crouch}{and~State~Univ.}$. Dept. of Physics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A description of a magnetic densimeter using an r. f. sensing coil based on similar designs by Beams and Senter is presented. The coil is used to sense the position of a small buoy floating in a liquid whose density is to be determined. The instrument's electronics is completely composed of solid state components. The densimeter was tested by making a calibration run on a National Bureau of Standards' sucrose sample. It was found to be capable of making density measurements to better than three parts per million.

HOLOGRAPHIC MICROSCOPY WITH APPLICATIONS TO WATER POLLUTION. S. P. Almeida and D. Del Balzo. Dept. of Physics; J. Cairns, K. L. Dickson, and Guy R. Lanza. Dept of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A prototype system utilizing laser optics techniques has been developed to make holograms of microscopic algae found in water samples. The system is used to carry out recognition studies of the various diatoms. The concentration of the different types of diatoms present in water helps to determine the degree of pollution present. Semi-automatic identification of the diatoms is an important step in reducing the time required for a pollution analysis. (This work was supported in part by the Manufacturing Chemists Association and The Center for Environmental Studies at Va. Polytechnic Inst. and State Univ.)

DYNAMIC NUCLEAR POLARIZATION IN A RARE EARTH DOUBLE NITRATE SALT. <u>C. E. BYVIK</u> NASA, Langley Res. Ctr., Hampton, Va. 23365, and D. S. Wollan Dept. of Physics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The dynamic polarization of hydrogen nuclei by the solid effect in single crystals of samarium-doped lanthanum magnesium nitrate (Sm:LaMN) has been studied theoretically and experimentally. We have re-derived the spin temperature theory of the solid effect, correcting errors in previously-published results, and showing that it leads to the same results as the rate equation approach in the special case of well-resolved, satellite transitions. Experimental enhancements of the proton polarization as high as 180 have been measured in Sm:LaMN at 9.2 GHz and liquid helium temperatures.

ELASTIC CONSTANTS OF α -Cual ALLOYS. L.S. Cain* and J.F. Thomas, Jr.*. Dept. of Physics, Univ. of Va., Charlottes-ville, Virginia 22901.

The three independent second order elastic constants and their temperature derivatives have been measured for single crystal α -phase CuAr alloys for compositions to 13 at .% Al. The elastic constant C_{44} increases linearly upon alloying over this entire range of Al content. The elastic constants $C_{11},\ C_{12},\$ and C $^{'}=\frac{1}{2}\ (C_{11}-C_{12})$ decrease linearly with increased Al content 2 to 7.5 at .% Al. For higher Al content, these constants decrease at a greater rate. The temperature derivatives of the three elastic constants are only weakly dependent on Al content.

The changes in the elastic shear constants extrapolated to $0^{\circ}K$ have been analyzed in terms of a generalized Fuchs theory of homogeneous deformation. We conclude that a conduction electron term must be included in calculating the shear constants of Cu along with the electrostatic and ion repulsion terms originally considered, and that changes in this conduction electron term with increasing \mathbb{A}^{1} content make a significant contribution to the changes in the elastic shear constants due to alloying. The results indicate an increase in conduction electron density with increasing \mathbb{A}^{1} content

(Research supported by the U.S. Atomic Energy Commission and by the National Science Foundation through its Institutional Grant Program.)

 $^{^1}$ J. W. Beams and A. M. Clarke, Rev. Sci. Instr. $\underline{33}$, 750 (1962).

²J. P. Senter, Rev. Sci. Instr. <u>40</u>, 334 (1969).

BOUNCING BALLS - A MONTE CARLO CALCULATION OF A HARO OISK SYSTEM'S PARTITION FUNCTION AT ALL OEMSITIES. Robert L. Coldwell and Coleman Blake, Physics Oept., Washington and Lee University, Lexington, Va. 24450

The method presented last year has been expanded to allow an arbitrary number of lattice points per particle, thus freeing us from the lattice gas limitations. A scheme has been devised to allow calculations in and through the phase change region and the free volume limit has been analytically and numerically shown to follow from this scheme in the limit of very high densities. The system's pressure can be calculated from this partition function, has been, and will be shown to be in good agreement with that found by earlier investigators who calculated the pressure directly.

ELECTROLUMINESCENCE IN GALLIUM PHOSPHIDE. Roger K. Crouch. NASA, Langley Research Center, Mail Stop 473, Hampton, VA

23365

When a p-n junction in gallium phosphide is forward biased, visible electroluminescence of relatively high efficiency has been observed. These gallium phosphide diode lamps offer the best characteristics for the emission of red and green incoherent light available at present. Since gallium phosphide is an indirect gap semiconductor, the indirect radiative transition rates are enhanced by the carefully controlled addition of impurities which interact strongly with the free carriers. The model for the red emission is radiative exciton recombination duc to an interaction of free carriers with oxygen-zinc, donor-acceptor, pairs located on nearest neighbor lattice sites. This recombination process has led to diodes with external quantum efficiencies as high as seven percent at room temperature. When nitrogen is introduced into GaP, it enters as an isoelectronic substituent for a phosphorus atom. The difference in electronegativity between the nitrogen and phosphorus gives rise to an interaction with the free carriers which produces radiative exciton recombination with a characteristic green emission. This process has led to room temperature external quantum efficiencies as high as 0.6 percent.

BERYLLIUM-LITHIUM COMPLEXES IN SINGLE-CRYSTAL SILICON. R. K. Crouch, J. B. Robertson, M. F. McNear.* NASA -Langley Res. Ctr., Hampton, Va. 23365, and T. E. Gilmer, Jr. Dept. of Physics, Va. Polytechnic Inst., Blacksburg, Va.

When lithium is thermally diffused at a temperature of 600° C into a beryllium doped silicon sample, two new acceptor levels are created in the band gap located at 106 meV and 82 meV above the valence band. In addition, the localized impurity vibrational band found at 500 cm⁻¹ in beryllium doped silicon is shifted to 516 cm⁻¹. The spectra indicate that the 106 meV center has a split ground state with the two levels separated by 1.2 meV. Quenching and annealing studies indicate that the 106 meV center is lithium closely associated with the Set I beryllium defect in silicon and the 82 meV is lithium closely associated with the Set II beryllium defect.

FERMI SURFACE OF α-COPPER-ALUMINUM ALLOYS - COM-PARISON OF OPTICAL AND POSITRON ANNIHILATION RESULTS. A.S. DeReggi* and R.S. Rea*, Univ. of Va., Charlottesville, Va. 22903

Recent positron-annihilation (PA) results 1 on $\alpha\text{-CuAl}$ alloys have led to the conclusions that the diameter of the neck of the Fermi surface (FS) is an oscillatory function of the Al concentration $\boldsymbol{\chi}\text{,}$ with the neck going off the hexagonal face of the Brillouin zone for χ > 10 at.%. Our optical measurements show instead a linear increase of the neck diameter, as long as no short-range order (SRO) exists in the samples. We find that SRO has the effect of reducing the neck diameter². Noting that several PA data points are in agreement with our optical results, while all others show deviations on the low side, we suggest that the anomalous PA results can be attributed to SRO. that the belly diameter also increases linearly with χ , leading to FS contact with X at the limit of stability of the α -phase. 1. K. Fujiwara and O. Sueoka. J. Phys. Soc. Japan

24, 467 (1968). 2. R.S. Rea and A.S. DeReggi, previous paper.

Research supported by the U.S. Atomic Energy Com-

CHALLENGE OF EXCITING THE OF GIANT RESONANCE MODE. J.M. Eisenberg and H.J. Weber* Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The collective giant resonance vibrations with spin-parity $J^P=0^-,1^-,2^-$ and isospin T=1 in light even-even nuclei lie in the range of 20-25 MeV. Photonuclear reactions are useful for the study of the pure isospin mode (L=1,S=0,T=1, $J^P=1^-$) and electroexcitation for the spin-isospin modes (L=1,S=1, $T=1,J^P=1^-,2^-$). The 0⁻ mode, however, has not been observed as yet for lack of an excitation mechanism and because of the nearby dominating spin-flip 1 mode. It is essential to use a predominantly scalar interaction as excitation use a predominantly scalar interaction as excitation mechanism which produces s-wave pions, e.g. the s-wave component of the inelastic $(\pi_1\pi^1)$ process in the $(\pi_1,2\pi)$ reaction on nuclei and, alternatively, a virtual photon with a large scalar component, as produced in electron scattering at high momentum transfer. Schematically, the transition matrix element may be written as $<(L=1,S=1)J^P=0^-|g\cdot p|0^+$, ground state>. Cross sections are calculated using the shell model and results for $^{\frac{1}{4}}$ He and $^{\frac{1}{6}}$ O are reported. (Supported by the National Science Foundation) by the National Science Foundation)

MEASUREMENTS OF NEUTRON POLARIZATIONS FROM THE 14N(d,n)150 MEASUREMENTS OF NEUTRON POLARIZATIONS FROM INC. N.Q., N. AND 15N(d,n)160 REACTIONS. R. P. Fogel* and S. T. Thornton. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901 Neutron polarization angular distribution for the ¹⁴N (d,n)¹⁵O and ¹⁵N(d,n)¹⁶O reactions have been measured with a

liquid helium neutron polarimeter and the Univ. of Va. 5.5 MV Van de Graaff pulsed accelerator. Ground and excited state neutron polarizations were obtained for a deuteron bombarding energy near 5.1 MeV.

The data are being analyzed in terms of direct reaction distorted wave theory. The $^{14}\text{N}(\text{d,d})^{14}\text{N}$ elastic differential cross section is being analyzed using a combination of optical and statistical models in order to obtain suitable wave functions for the distorted wave calculations. This analysis will be discussed for the $^{14}{\rm N}(d,n)^{15}{\rm 0}$ reaction. (Work supported in part by the National Science Foundation through the Univ. of Va. Center for Advanced Studies and by the Research Corporation)

PHOTOELECTRIC ASTROMETRY. <u>L. W. Fredrick</u>, Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

Experiments using a Ronchi grating to modulate radiation at the focal plane of a telescope have shown the feasibility of a new technique for recording stellar positions, colors, and magnitudes directly at the telescope bypassing the traditional photographic plate. Present studies using a cosinusoidal crossing function as an approximation to the modulated light intensity lead to an expected accuracy of ± 0.1 micron in positions and ± 0.01 magnitude in colors and magnitudes. The faintest star reached is determined solely by the integration time used. (This work is supported by NASA.)

FOURIER SPECTROSCOPY MEASUREMENT OF BRILLOUIN LINE WIDTH OF BENZENE, J.A. Garner*and E.M. Kiess Dept. of Physics, Hampden-Sydney Col. Hampden-Sydney, Virginia 23043 The Michelson Visibility method has been in-

The Michelson Visibility method has been investigated for the purpose of measuring Brillouin line widths and shapes. In this paper data are presented for 6328Å He-Ne laser light scattered by Benzene. Visibilities were measured with a Michelson interferometer. The data are consistent with Lorentzian lines of full width at half intensity of 190 MHz.

1. E.M. Kiess, J. Opt. Soc. Am. <u>60</u>, 1197 (1970)

THE CENTROID METHOD OF NUMERICAL INTEGRATION. I. J. Good, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061; and R. A. Gaskins, Dept. of Mathematics, Hampden-Sydney Col., Hampden-Sydney, Va. 23943

matics, Hampden-Sydney Col., Hampden-Sydney, Va. 23943

If a function f(x), of a p-dimensional vector x, can be expanded by Taylor's theorem at the centroid x of some region, the expansion being valid in the region, then the integral of over the region can be expressed in terms of the derivatives of f combined with the moments of inertia of the region. This simple method of integration has perhaps been overlooked except for the one-dimensional case, when it reduces to the midpoint method. Even the midpoint method is not mentioned in most textbooks, although it is usually more accurate, for a given amount of calculation, than the trapezoidal method.

Since any non-pathological bounded region can be approximated by a collection of simplexes, it is useful to have a formula for the moments of inertia of a simplex about its centroid. From a mathematical point of view, the solution of this problem is the main contribution of this paper. It was discovered by man-machine synergy.

A numerical example is given for the integration of the multinormal density, with measures of the proportional accuracy. FORTRAN programs are included. THE RELATIONSHIP BETWEEN TWO FAST FOURIER TRANSFORMS. I. J. Good. Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Owing to the ubiquity of the Fourier transform in the hard sciences, the Fast Fourier Transform (FFT) has become one of the most familiar of computer algorithms. The saving in computer time is such that the FFT has been described, for example, as "an economic breakthrough in geophysics." Even when computers become much faster the FFT will remain useful because it can be applied to Fourier transforms in more than one dimension, and because in some applications, such as in X-ray crystallography, it has to be computed many times. Its usefulness was not generally recognized until the publication of a paper by J. W. Cooley and J. W. Tukey (1965) who had been stimulated by the practical requirements and by a paper by I. J. Good (1958). The methods used by these writers were not the same, and it turned out that the Cooley-Tukey method had been largely anticipated by earlier writers whose work had been largely overlooked. Good's method depended on noticing that a simple algorithm of Yates, used in factorial experiments, could be regarded as a special case of a discrete Fourier transform. The main purpose of the present paper is to show as simply as possible the relationship between the two basic FFT's, and also to generalize one of the methods somewhat. The method applies to all those linear transformations whose matrices are expressible as direct products, preferably of sparse matrices.

MUONIC X-RAY STUDY OF THE QUADRUPOLE MOMENT OF 197 Au.
R. C. Hart*, D. A. Jenkins*, and R. J. Powers*, Dept. of
Physics, Va. Polytechnic Inst. and State Univ., Blacksburg,
Va. 24061 and P. Martin*, G. H. Miller*, and R. E. Welsh*,
Col. of William and Mary, Williamsburg, Va. 23185
We have used the byserfine structure of 22 cm. and 15 cm.

We have used the hyperfine structure of $2p_{3/2} \rightarrow 1s_{1/2}$ and $3p_{3/2} \rightarrow 2s_{1/2}$ transitions in muonic $19^7 \mathrm{Au}$ and the absolute energies of atomic transitions to or from the 1s, 2p, and 2s levels to measure the quadrupole moment. Two models for the quadrupole density have been used to infer the quadrupole moment.

EULER'S SERIES APPROXIMATIONS OF π AND COMPUTER ERROR. Keth A. Hope*, William M. Sanders, and Gerald R. Taylor,Jr. Depts. of Mathematics and Physics, Madison College, Harrisonburg, Virginia 22801

Two Euler's series approximations of π are evaluated on an IBM 1130 computer. The best numerical approximation of π obtained by Euler's series is good to only four significant digits because of the characteristics of the series and the intrinsic error in the IBM 1130 computer. The number of significant digits from the computer is seen to have an inverse relationship with the number of arithmetic operations performed. The absolute error of the IBM 1130 computer is examined through summation and multiplication processes. This absolute error is observed to change with different numbers; however, the relative error is primarily a function of the number of arithmetic operations performed. Due to the intrinsic error of the computer it is shown that all series appear to converge numerically.

Also the absolute errors from the IBM 1130 computer and 1BM 360/50 computer are compared, indicating the IBM 1130 computer generally accumulates less absolute error than the IBM 360/50 computer. All computations are accomplished through programs written in FORTRAN IV.

CAN ONE SEE ISOBARS IN NUCLEI? P.K. Kabir*, <u>N.R. Nath</u>*, and H.J. Weber*. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

Until recently, most analyses of nuclear phenomena ignored the internal structure of the nucleon and the possibility of its excitation. Forward proton production in $\pi^- d \rightarrow p \Delta^-$ collisions is particularly useful as a probe of the 33-isobar $(\Delta \Delta)$ configuration of the deuteron. This reaction is analyzed in terms of a Δ^{++} -exchange mechanism. The $(\Delta \Delta d)$ vertex is estimated from the usual deuteron wave function and the NN+ $\Delta \Delta$ amplitude in the one-pion exchange approximation. Cross sections for various pion energies are reported. (Supported by the National Science Foundation through the Center for Advanced Studies and an Institutional grant)

STUDY OF LIMITING DISTRIBUTIONS IN MULTIPION EVENTS AT HIGH ENERGIES. T. W. Kephart and M. A. Ijaz. Physics Department, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061

The longitudinal momentum distributions $(p_{\hat{\ell}})$ of pions produced in high multiplicity events at high energies has been discussed a great deal in recent years. Feynman has suggested a limiting $p_{\hat{\ell}}$ distribution when center of mass energy of the interacting particles becomes very high. We have analyzed $p_{\hat{\ell}}$ spectra of pions produced in $\pi p_{\hat{\ell}}$ pp and $\bar{p}n$ experiments in the energy range of the presently existing accelerators. The center of mass $p_{\hat{\ell}}$ distributions have been fitted with an expression

$$\frac{d\sigma}{dp_{\ell}} = \frac{A}{\sqrt{p_{\ell}^2 + B}}$$

where A and B are parameters of the fit. We find that parameter B which controls the shape of the p_{ℓ} distribution is very nearly the same for all p_{ℓ} distribution in a limited range. This suggests evidence for Feynman's scaling hypothesis.

¹R. P. Feynman, Phys. Rev. Lett. <u>23</u>, 1415 (1969).

EXCITATION OF H-ATOMS TO np AND nd STATES BY FAST PROTONS.

G.S. Khandelwal, J. E. Shelton*, and W. M. Pritchard*. Dept of Physics, Old Dominion Univ., Norfolk, Va. 23508

The form factor for excitation by incident protons of hydrogen atoms to any state nl as a function of momentum transfer has been given by Mott and Masseyl. Inokutil has expressed this inelastic form factor in terms of a power series in the momentum transfer. We have used these results to obtain the cross sections in simple algebraic form to order $\frac{1}{E^3}$

high incident energies ${\tt E}$ for excitation to any ${\tt np}$ and ${\tt nd}$ states of the H-atoms.

N.F. Mott and H.S.W. Massey, 1965, Theory of Atomic Collisions, (Oxford: Clarendon Press).

²M. Inokuti, Argonne Nat. Lab. Radiol. Phys. Div. A. Rep., July 1965-June 1966, No. ANL-7220. COMMENTS ON THE FORMATION OF THE SOLAR SYSTEM. Shiv S. Kumar, Univ. of Va., Dept. of Astronomy, Charlottesville, $\overline{\text{Va.}}$ 22903

The stability of periodic orbits in the elliptic restricted problem of three bodies has been studied recently by Shelus and Kumar (Astron. Journal 75, 315, 1970). The relevance of this study to the problem of the formation of the solar system will be discussed in this paper. The stable orbits for a body of infinitesimal mass exist only near one or the other of the two primaries, or very far from both of them. Therefore, we can have stable orbits for the planets in a solar system if the ratio of the mass of the most massive planet to the mass of the central star is small ($\sum_{j \in \mathcal{J}} 1$), and if the most massive planet moves around the central star in an elliptical orbit with small eccentricity ($\mathcal{L} \times (\mathcal{L} \times \mathcal{L})$).

The mass of Jupiter (in terms of the mass of the Sun) is 0.001, and its orbital eccentricity is 0.05. If we depart from these properties, our planetary system becomes unstable. Since our planetary system has survived for a period of $4.5 \mathrm{x} 10^9$ years, the above-mentioned properties of the most massive planet (Jupiter) are original to the system.

AN OPTICAL SYSTEM FOR HOLOGRAPHY OF MOVING SCENES AT HIGH VELOCITY.Robert L. Kurtz, MSFC, Huntsville, Ala. and H. Y. Loh, Dept. of Physics, VPI&SU, Blacksburg, Va. 24061

Any motion of the holographic scene during the exposure of a hologram, results in a spatial modulation of the recorded fringe contrast. Upon reconstruction this produces a spatial amplitude modulation which degrades the image. If the total scene displacement causes an optical path length change of $\frac{1}{2}$ wavelength, image degradation is generally prohibitive.

An optical system has been developed which uses an elliptical configuration having a unique orientation with respect to the velocity vector of the scene. This system, with properly chosen parameters, will allow total scene displacements greater than 2000 μ , while constraining the optical path length change to approximately 1/8 wavelength. The functional form of system dependence will be given along with experimental results showing front surface detail recorded holographically from a scene with velocity of 175 m/sec. Using these results a predicted upper limit on scene velocity, sufficient to allow resolution of front surface detail from a scene, will be given.

NUCLEAR (-RAYS FOLLOWING MUON CAPTURE IN EVEN-EVEN, INTER-MEDIATE 2 NUCLEI. G.R. Lucas, Jr.*, P. Martin*, G.H. Miller*, and R.E. Welsh, Dept. of Physics, College of William and Mary, Williamsburg, Va. 23185: and D.A. Jenkins and R.J. Powera, Dept. of Physics, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

From observations with Ge(L1) detectors of the delayed 3-rays obtained in muonic X-ray studies of \$142_{Ce}\$, \$140_{Ce}\$, \$138_{Ba}\$, and \$120_{Sn}\$, we have determined the branching ratios to excited nuclear states formed after the muon capture proceas. In agreement with Backenstoss, et. al., we observe the dominance of neutron emiasion following muon capture, with the probability of single neutron emission being highest. The probability of forming a particular excited state in an isotope was in general about inversely proportional to the energy of the atate.

Energy level schemes will be presented for several of the nuclei formed, and the possible effect of the closed neutron shell (N=82) on the results from the Cerium and Barium experiments will be discussed. (Work supported in part by the National Aeronautics and Space Administration and the National Science Foundation)

¹G. Backenatosa, et. al., Nuc. Phys. <u>A162</u>, 541 (1971)

LASEM INDUCED MODULATION OF OPTICAL ABSORPTION IN ZnSe. M. W. Major , Dept. of Physics, Univ. of Richmond, Va. 23173

Changes AGin the optical absorption of ZnSe at room temperature have been detected as a result of generation Of electron-hole pairs in the sample by a chopped (114 Hz) 6 mw He-Ne laser. Synchronous detection of the modulated primary beam is used to study the relaxation kinetics for laser pulse durations of 2.5 ms. Modulation is of the order of a few parts in 10³.

Spectra of the magnitude of the <code>x-modulation</code> in the same samples have been made in the visible range (1.6-2.8 ev) by the author in the NASA Langley laboratory of E. J. Conway. Comparison of these with simple absorption spectra reported recently by Stringfellow & Bube for p-type ZnSe:Cu suggests that multivalent copper impurity may be important in establishing a model for the modulation observed, via Cu⁺ and Cu⁺² substitutional on the Zn sublattice at several levels in the band gap. The laser has a photon energy of 1.96 ev so that direct transitions over the 2.7 ev band gap should be excluded.

(Aided by NASA grant NGR47-023-001)

ANALOG COMPUTER SOLUTION TO EQUATIONS OF MATHEMATICAL PHYS-ICS. C. C. Mercer, C. E. Mercer, and R. J. Onega. Dept. of Physics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The application of analog computers to the solutions of equations in the field of physics has been studied. It is concluded that the modern electronic analog computer is a very useful tool both as a teaching aid and for research in some areas. Linear and nonlinear differential equations can be solved on the analog.

As an example, a graphical solution for the steady state electrodiffusion equations for a simple membrane has been obtained. These equations are

and

equations are
$$\frac{dn_k}{dk} - Z_k Bn_k E = -\frac{J_k}{Z_k U_k RT}, k = 1, \dots, N$$

$$\frac{dE}{dx} = \frac{F}{\varepsilon} \sum_{k=1}^{N} Z_k n_k$$
e concentration in moles per volume of the

 \mathbf{n}_k represents the concentration in moles per volume of the type k ion at position x, \mathbf{Z}_k is the valence, E is the electric field at position x, \mathbf{j}_k is the current density of the ions of type k, $\beta\text{=F/RT}$ where F is Faradays constant, R is the universal gas constant and T is the absolute temperature.

 R. A. Arndt, J. D. Bond, and L. D. Roper. Biophysical Journal, 1971 Vol. 11, No 3, pp 265-280.

AIR POLLUTION MONITOR. Siegfried S. Meyers.

Dept. of Physics, Madison College, Harrisonburg, Va. 22801. An instrument capable of continuous monitoring of air pollution from smoke-stacks and automotive exhausts employs the principle of the Lumen-Hour Integration Meter. Clean air is compared with polluted air passing between a white light source and a photoconductive light sensor. The readout meter digitally registers the integrated total in Lumen-Hours for a pre-determined time interval. High readings indicate clean air; low readings indicate polluted air and is expressed as a percentage. Attachment of a hose between an automobile's exhaust pipe and the Smoke Trap of the meter registers readings of the presence of particulate hydrocarbons accompanying other invisible pollutants, like: CO2; CO; H2S; NO2; SO2; etc. Exhaust pollutants intercept a light beam shining upon a photoconductive sensor. An automatic time-switch first samples clean air and then samples polluted air for equal time intervals. In operation, a miniature dc. motor drives a digital readout counter in series with a dc. voltage source, a photoconductive lightsensor, and a zero-adjusting rheostat. The sensor's electrical resistance increases when particulate pollutants condense within a glass Smoke Trap positioned in the light path which causes the counter's speed to decrease. Counter readings are then expressed as a ratio between clean and polluted air and converted to a percentage caused by particulate pollution. For a complete determination gas analyzers would be required.

DOES A PION PROBE NUCLEAR SHORT-RANGE CORRELATIONS? J.W. Morris, Jr.* and H.J. Weber*. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The angular, single-nucleon energy distributions and total 2P-pion absorption rates are calculated for the reaction $^{12}(\tau^-,2N)$ and compared with experimental data. A partial wave analysis is used which describes the final-state scattering in terms of an optical potential and a two-body residual nuclear interaction. The effects of the short-range correlations of the absorbing bound nucleon pair on the absorption rates are discussed and compared with those of the competing final-state interaction between the two emitted nucleons. (Supported by an Institutional NSF Grant and the National Science Foundation)

MODES OF OSCILLATION OF A SUPERCONDUCTING POINT-CONTACT COUPLED TO A RESONANT CIRCUIT. John M. Pickler* and Bascom S. Deaver, Jr., Dept. of Physics., Univ. of Va., Charlottes-ville, Va. 22901

When a voltage $V_{\rm O}$ is maintained between a pair of weakly-linked superconductors there is an oscillating current between the superconductors at frequency v given by the Josephson relation hv = 2eV_{\rm O}. We have been studying the oscillations of an adjustable Nb point-contact coupled to a tuned circuit resonant at $v_{\rm T}=60$ MHz by observing the output from the circuit as a function of voltage across the point-contact. We find output from the tuned circuit at bias voltages V = $\frac{m}{n}$ Vo where Vo = hv_r/2e and m and n are integers. We observe sequences of voltages with n varying from one to more than 50 indicating that the oscillation is a series of abrupt current pulses with high harmonic content. We also observe values of m from one to more than 30 corresponding to phase shifts between the two superconductors of m(2\pi) for each cycle of the oscillation. In addition, we find that m is an almost continuous function of temperature and we will discuss a possible explanation for this surprising behavior. (Research supported by the Office of Naval Research.)

SELF DETECTION OF THE JOSEPHSON OSCILLATION IN SUPERCONDUCT-ING POINT-CONTACTS. Marcello Puma* and Bascom S. Deaver, Jr., Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901.

We have measured the I-V curve and its second derivative as a function of temperature for a larger number of Nb point-contacts. We find step-like features at voltages V = $\frac{\Delta}{ne}$ where 2Δ is the superconducting energy gap and n an integer. In addition, we find steps at voltages up to 10Δ . The voltage at which a particular step occurred varies with temperature and two general types of temperature dependence are found. Steps for which V $\leq \frac{2\Delta}{e}$ follow the temperature dependence of the energy gap $\Delta(T)$. Steps with V > $\frac{2\Delta}{e}$ vary much faster than $\Delta(T)$. If we assume that whenever there are oscillating currents in the point-contact at frequency hv = 2Δ there will be an enhanced current through the point-contact, we can account for all the features we observe with a simple model which will be described. (Research supported by the Office of Naval Research.)

EFFECT OF SHORT-RANGE ORDER ON THE OPTICAL PROPERTIES OF α -COPPER-ALUMINUM. R.S. Rea*, and A.S. DeReggi*, Univ. of Va., Charlottesville, Va. 22903

We have discovered that the optical properties of α -CuAl are strongly affected by short-range order (SRO) which prevails in crystals with a reasonably gentle thermal history below 300°C and Al concentration in excess of $^{\circ}$ 8 at. $^{\circ}$. Hence the imaginary part of the dielectric function (ϵ_2) of this alloy provides detailed information about the ordering process at the electronic energyband level. It is observed that SRO has two main effects on ϵ_2 : 1) The interband edge around 2 eV changes slope upon ordering, and 2) a prominent absorption structure around 5 eV shifts rigidly to higher energy by $^{\circ}$ 1/2 eV. Both effects, together with a lack of displacement of an intermediate-energy peak, indicate a distortion of the bands. Within a simple model of the alloying process, ordering can be understood mainly in terms of a change in the V₁₁₁ Fourier component of the potential.

Research supported by the U.S. Atomic Energy Commission.

CARRIER SCATTERING MECHANISMS AND THICKNESS EFFECTS IN ELECTRICAL CONDUCTION IN THIN FILMS. Billy W. Sloope, Physics Dept., Va. Commonwealth Univ., Richmond, Va. 23220.

While the effect of film thickness on electrical conduction has been rather satisfactorily explored for metals, such is not the case for semiconductors. The only case reported has been for n-type Ge with acoustical phonon scattering. This case lead to a thickness correction factor similar to that derived for metals. However, since semiconductors are influenced to a greater degree than metals by the various scattering mechanisms, the thickness dependence for other scattering mechanisms has been analyzed for p-type Ge. The general results for various combinations of scattering mechanisms will be presented and several examples discussed. The thickness for which the thin film effect is appreciable depends on the scattering mechanisms.

SOURCES OF FAST POLARIZED NEUTRONS. <u>J. R. Smith</u>* and S. T. Thornton. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The Univ. of Va. 5.5 MV Van de Graaff pulsed accelerator has been used with the neutron time-of-flight method to measure the polarization of neutrons from the $T(p,n)^3 He$, $D(d,n)^3 He$ and $T(d,n)^4 He$ reactions. A liquid helium neutron polarimeter was used to determine the neutron polarizations. Polarization angular distributions were obtained for each reaction at several energies between 1 and 5 MeV.

The experimental method and results will be presented. The best sources of polarized neutrons for neutron scattering studies will be discussed by considering polarization magnitudes and reaction intensities. (Work supported in part by the National Science Foundation through the Univ. of Va. Center for Advanced Studies and by the Research Corporation)

THE FOURIER TRANSFORM IN PHYSICAL MEASUREMENT OF DIAGNOSTIC X RAY PERFORMANCE. E. E. Stickley, Radiation Physics Division, Medical College of Virginia Commonwealth University, Richmond, Va., 23219.

Richmond, Va., 23219.

The aim of diagnostic roentgenology is to obtain a definitive radiograph of anatomical structures with the least necessary exposure to the patient. Several components of the x-ray system exert controlling influences on image definition (resolution and contrast) although this depends also on the nature of the part being examined and a number of less significant parameters. To provide a guide in the practical selection and matching of equipment and materials as well as operating factors, the modulation transfer functions of the several elements can be used, if they are determined separately. In many cases the most significant component is the x-ray source itself, i.e., the size of the focal spot in the x-ray tube. A new test, employing leaded grid phantoms of special design, can be used to provide information on this parameter. Simple and rapid exposures on standard film are sufficient to demonstrate focal spot configuration under the usual range of operating conditions. Sample radiographs illustrate the correlation of radiographic results with focal spot measurements in both ideal and other situations; relationships of other physical factors are also shown.

FOURIER TRANSFORM SPECTROSCOPY DETERMINATION OF THE NOR SPECTRUM OF SOLID NITROGEN. Bruce Strachan, P.C. Canepa* and A.S. DeReggi*, Univ. of Va., Charlottesville, Va. 22903

The envelope of NQR echoes in $\alpha-N_2$ has been measured at 4.2°K as a function of applied field from 0 to $^{\circ}$ 100 gauss. In the earth's field, complicated modulations of the echo envelope are observed which are attributed to the superposition of Zeeman patterns corresponding to the four distinct molecular orientations in the unit cell. At fields above $^{\circ}$ 10 gauss the modulation of the echo envelope contains only one prominent frequency which is field-independent for fields in the range 10 gauss < H < 100 gauss. This observation is discussed in terms of the available information about the crystal structure.

Research supported mainly by the National Science Foundation through an Institutional Grant. Fourier transform computations aided by a Themis Grant. DISTRIBUTION OF QUANTIZED FLUX STATES IN SUPERCONDUCTING CYLINDERS. Wayne D. Willis*, William L. Goodman* and Bascom S. Deaver, Jr., Dept. of Physics, Univ. of Va., Charlottesville, Va., 22901

When a hollow superconducting cylinder is cooled through its transition temperature in an applied magnetic field $\rm H_{0}$, currents are induced in the walls so that for every closed path in the superconductor

path in the superconductor $\phi = \oint \frac{4\pi \lambda^2}{c} \frac{3}{3} \cdot d\bar{s} + \phi = n \; \phi_0$ where j is the supercurrent density, λ the penetration depth, ϕ the magnetic flux within the path, n an integer and ϕ_0 the flux quantum $hc/2e = 2.07 \; x \; 10^{-7} \; G \; cm^2$. We have measured the distribution of magnetic flux ϕ as a function of H_0 and find that for most values of H_0 the entire cylinder is in the same quantum state. For some values of H_0 there is a mixed state with bands along the cylinder in states differing by one flux quantum. When H_0 is changed the distribution of bands changes so that the average flux in the cylinder appears to vary almost continuously with H_0 . We have also measured the variation of ϕ with temperature and find a continuous, reversible change by just the amount required to maintain the constancy of the fluxoid ϕ . This variation was observed in a cylinder with n = 1 and thus corresponds to an adiabatic variation of a macroscopic quantum state. (Research supported by the National Science Foundation.)

Section of Biology

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12-14, 1971, Blacksburg, Virginia

SOME EFFECTS OF LOCALIZED INTERMODE SEGMENT AND ENTIRE-

SOME EFFECTS OF LOCALIZED INTERNODE SECMENT AND ENTIRESHOOT IRRADIATION ON SURVIVAL AND MORPHOLOGY OF SUNFLOWER PLANTS. D. Bankes. Christopher Newport Col.,
Newport News, Va. 23606

The LDico was 3.5 ER following segment and 2.5 ER
following on ire-shoot X-irradiation.

Irradiate's segments wree constricted approximately
10 toys after irradiation. Constriction was due to much
cambial activity above the segment, little in the segment,
and a noderate amount below the segment. Roots formed
a' two the segment and grow to the outside of the stem.

Irradiated segments, 20 - 60 days after irradiation,
income hypertrophic, due to proliferation of cells from
the cambium. Pith became necrotic, and tumor-like
structures grow in the cavity.

structures grew in the cavity.

In one above the irradiated segment, wyler vessels were small, and some were oriented transversely. Few sieve tures and companion colls differentiated sleve three and companion colls differentiated in the secondary phicen. Numerous and very large oil ducts formed in the phicem and cortex. Cork combin differentiated in secondary phicem after the spidernis, cortex, and primary phicem disappeared. Although the thouse above irradiated segments is probably reduced numbers and size of xylem vessels, transverse orientation of vessels, and disruption of xylem configuity to reduce the turner in the configuity of the configuration of the configu

continuity by roots and tumors in and just above the irradiated segments.

A STUDY OF THE SOIL PH AND SEED GERMINATION CONDITIONS FOR Rhus typhina and Rhus glabra IN HENRICO COUNTY, VIRGINIA AND ALLEGANY COUNTY, MARYLAND. P. C. Bergey and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va.23220

Studies of the germination of Rhus typhina and R. glabra, indicate that some form of pretreatment appears necessary to overcome the impermeability of the seed coat. Various pretreatments tested consisted of prechilling, boiling, scarification and soaking in concentrated sulfuric acid. The sulfuric acid soak and scarification methods have produced the best germination levels. R. $\underline{\text{glabra}}$ has a germination level of 35% when treated with sulfuric acid and 45% when scarified. Prechilling alone has no favorable effect on germination and prechilling is not necessary to obtain germination whether used as a separate pretreatment or used as a combination pretreatment.

Preliminary germination tests were conducted without seed pretreatment for R. glabra in pH solutions ranging from 4.01 to 10.01. Germination occurred in all solutions except that

of pH 10.01.

Soil samples were collected from stands of R. typhina near coal mine tailings in Allegany Co., Md. and from stands of R. glabra in Henrico Co., Va. and tested for pH. The soil pH range for R. typhina (Md.) was 4.34 to 7.85. R. glabra (Va.) had a range of 4.36 to 5.14. (Aided by VDA&C)

SALINITY TOLERANCE OF THE PRAWNS, PALAEMONETES VULGARIS AND P. PUGIO, AND ITS RELATIONSHIP TO THE DISTRIBUTION OF THESE SPECIES IN NATURE. Michael W. Bowler and Arthur J. Seidenberg. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

Two prawns, Palaemonetes vulgaris and P. pugio were found to be extremely abundant in the York River near Gloucester Point, Virginia. Observations in the literature suggested that P. pugio is usually found in less saline habitats than P. vulgaris.

At all low salinity conditions tested (1.0, 2.0, and

3.0 ppt (parts per thousand), P. <u>pugio</u> was more tolerant than P. <u>vulgaris</u>. At high test salinities (36.0 and 40.0 ppt), the relationship was reversed; P. vulgaris was more tolerant than P. pugio. The differences in their tolerances were most pronounced at the extremes tested, i.e., at 1 ppt and 40 ppt.

A field study was performed (24 April 1971) to determine the distribution of these species in nature. At Gloucester Point (salinity 14 ppt), 44% of the prawns present were P. pugio. At Clay Bank (salinity 7 ppt) on the York River, 85% of the prawns were P. pugio. In the Mattaponi River (0 ppt), all the prawns collected were

The difference in their salinity tolerance probably acts to help segregate these two species in nature where their distributions overlap. This may be very important in reducing competition between these two species, which other-wise have very similar niche requirements. THE ANAEROBIC RESPONSES OF RAINBOW TROUT (Salmo gairdneri)
DURING GRADUAL HYPOXIA AT TWO ACCLIMATION TEMPERATURES (50
AND 150 C). Dennis T. Burton. Dept. of Biology, Virginia
Polytechnic Institute and State University, Blacksburg, Virginia 24061

Both lactic acid and free short-chain fatty acids have been suggested as anaerobic endproducts in trout exposed to environmental hypoxia. This study was undertaken to deter-mine whether or not lactate and/or free short-chain fatty acids occurs in rainbow trout subjected to gradual hypoxia. Hypoxia was induced by lowering the oxygen tension of water approximately 9 mm Hg, at half hour intervals, from 147 mm Hg down to 65 mm Hg for the warm acclimated trout (15° C), and from 147 mm Hg down to 19 mm Hg for the cold acclimated trout (5° C). Skeletal muscle and liver were analyzed for lactate, pyruvate, and free short-chain fatty acids.

The metabolic response of warm and cold acclimated trout during hypoxia was a gradual increase in lactate in both muscle and liver. Pyruvate concentrations decreased sigmuscle and liver. Pyruvate concentrations decreased significantly in muscle at approximately the same ambient oxygen tension at which lactate increased. No change occurred in liver pyruvate concentrations. No free shortchain fatty acids were found in either tissue of warm or cold acclimated trout. The shift from aerobic to anaerobic metabolism (as determined by an increased lactate/pyruvate ratio) occurred between 80-90 mm Hg in the warm acclimated trout, and between 40-50 mm Hg in the cold acclimated trout. FURTHER STUDIES WHICH SUPPORT THE MUCOUS COAGULATION-SUFFOCATION HYPOTHESIS IN FISH EXPOSED TO ACUTELY TOXIC CON-CENTRATIONS OF ZINC. Dennis T. Burton, Alma H. Jones*, and John Cairns, Jr. Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Institute and State University, Blacksburg, Va. 24061

This study was conducted to further test the hypothesis that coagulation of mucous on the gills and/or cytological damage to the gills of fish exposed to acute zinc toxicity kills them by suffocation. Burton (Abstract in this Journal) has shown that rainbow trout (Salmo gairdneri) suffocated by exposure to low oxygen tensions have large increases in skeletal muscle lactate concentrations with subsequent reductions in muscle pyruvate. Large increases also occur in liver lactate with no change in pyruvate concentrations.

Rainbow trout were exposed to a concentration of 40 mg $Zn^{++}/1$ in a well oxygenated, continuous water flow system. Skeletal muscle and liver lactate and pyruvate were measured in control fish and fish killed by Zn^{++} . Zinc-killed fish had a 170% increase in muscle lactate when compared to controls and a 60% decrease in pyruvate. Liver lactate increased 460% in zinc-killed fish when compared to controls. In contrast to hypoxic-stressed fish, a 30% decrease in liver pyruvate occurred in zinc-killed fish.

A comparison of lactate and pyruvate changes in muscle and liver of trout subjected to Zn⁺⁺ and Zn⁺⁺ plus MS-222 (10 mg/l) has shown that muscle and liver lactate concentrations are lower in the Zn⁺⁺ plus MS-222 fish than the Zn⁺⁺ exposed group. This suggests that part of the lactate accumulation may be due to exercise rather than suffocation alone.

PATTERN RECOGNITION OF DIATOMS BY LASER HOLOGRAPHY IN BIOLOGICAL MONITORING OF POLLUTION. John Cairns, Jr., Kenneth L. Dickson, <u>Guy R. Lanza</u>, S. P. Almeida, and Donald Delbałżoo, Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061
One major disadvantage in assessing the effects of pollu-

One major disadvantage in assessing the effects of pollutional stress upon aquatic communities lies in the time required for data feedback. Attempts to characterize and record the community structure of algae in a short time period utilizing pattern recognition by laser holography are underway in our laboratories. Diatoms both grown in laboratory culture and collected from the field have been studied. Efforts are being directed towards developing a technique which would provide a means of the rapid detection of alterations in both (1) community diversity; (2) the types of species present; following pollutional stress. (Research supported by Manufacturing Chemists Association.)

OXYGEN EQUILIBRIUM PROPERTIES OF COELOMIC HEMOGLOBIN IN THE POLYCHAETE <u>GLYCERA</u> <u>DIBRANCHIATA</u>. <u>J. A. Carhart</u>* and C. P. Mangum. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The Atlantic bloodworm, <u>Glycera dibranchiata</u>, lives in anoxic marine sediment, reaching maximum population density near the low water mark. It has a degenerate vascular system and contains large quantities of hemoglobin within nucleated corpuscles in the coelomic fluid. Estimates were made of the extent to which coelomic fluid participates in respiratory transport. Whole animals were equilibrated to various p02's and the gas content of the coelomic fluid measured. The resultant "oxygen equilibrium curve" reveals an extremely high p50 and indicates that the hemoglobin apparently functions in oxygen transport at intermediate and high p02's. This figure for hemoglobin in coelomic fluid of intact animals differs significantly from the p50 of the hemoglobin in solution.

PIGMENTS IN THE AVIAN EGG SHELL: CAMOUFLAGE OR LIGHT SCREEN? Marilyn A. Coleman*, Anne Dumper*, Carole Luckner*, Roger A. McNabb*, and Cletus M. Sellers, Jr. Dept. of Biology, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061.

Two groups of Japanese quail eggs were matched for size and pigmentation. One group of eggs had the melanin spots removed by washing with tepid tap water; naturally pigmented eggs, washed only on the bottom, served as the controls. The surfaces of all eggs were sterilized with antiseptic hatching solution. Randomly grouped eggs were incubated with continuous illumination for six days, twelve inches from a 100 watt incadescent bulb.

Embryos of depigmented eggs developed faster but weighed significantly less than the control embryos. The more rapid development was evident at the first 24 hour observation. By the end of the six day study, the experimental embryos were 24 hours more advanced in their development than the controls. Despite the more rapid development, internal egg temperature was about $1^{\circ}\mathrm{C}$ lower in the depigmented eggs than in the control eggs, under the same conditions.

SELECTIVE CUTTING PROCESSES IN A COASTAL PLAIN FOREST. Harold N. Cones, Jr. Dept. of Biology, Christopher Newport Col. Newport News, Va. 23606

Point quartering of a 328 acre forested tract in Newport News, Va. was used to evaluate selective cutting by a commercial logger during a "clean-cut" lumbering operation. Five transects were analyzed before and after cutting; a sixth through an unlogged area serving as a control. The transects showed virtually complete removal of the commercially important Pinus taeda with only sporadic cutting of large hardwoods such as Quercus alba. Uncut trees were found to be damaged, diseased, or stunted.

It is postulated that under natural conditions a genetically inferior hardwood forest would arise from the cut over area.

ELECTRICAL POTENTIALS IN THE EPITHELIUM OF THE CTENOPHORE MNEMIOPSIS LEIDYI. D. W. Corson, Jr.* and J. F. Case*. Col. of William and Mary, Williamsburg, Va. 23185 and Marine Biological Lab., Woods Hole, Mass. 02638 Electrical activity in ctenophores is associated with

Electrical activity in ctenophores is associated with cell-to-cell transmission in the ctenes and apical organ and possibly in local muscle responses and with the nerve net control of ctene inhibition, muscle activity and lumin-escence. The potentials associated with cell-to-cell transmission can be isolated by blocking the nerve net with Mg⁺⁺. Periodic concerts of potentials of about 50 V occurred on both the ctene rows and the surrounding epithelium. These potentials are not associated with the beating of the ctenes or with bioluminescence. In some instances they could be mechanically and electrically induced. In addition, mechanical stimulation produced an action potential associated with the ctenes alone. Of various pharmacological agents tried, only sodium glutamate appeared to intensify activity. Ephedrine inhibited the response to mechanical stimulation; and lowering of the Ca⁺⁺ level made the concerts more erratic and reduced the size of the potentials.

EVALUATION OF SOME SPECIES DIVERSITY INDICES AND CURVES. M. D. Dahlberg. Va. Inst. for Scien. Res., Richmond, Va., 23229

Species diversity indices and graphs have been widely used to represent the structure of plant and animal populations. Studies of diversity of Georgia estuarine fishes has resulted in an evaluation of four indices and two graphs and the parameters that they are based on. Strong dominance of a species in the autumn reduced the relative abundance indices (evenness, equitability) but not the richness or Shannon indices. The Shannon index combines the relative abundance and richness components.

Substitution of size parameters (weight, length) for individuals produced different results for indices, dominance-diversity curves, and "lognormal" curves. Size parameters more accurately represent the energy distribution among the species and must be used to properly weigh the importance of the species unless they are all approximately the same size. Number of individuals produces a truncate "lognormal" curve while size parameters produce a somewhat normal distribution, indicating a large number of species of intermediate importance. Dominance-diversity curves indicate a high diversity when size parameters are used.

FISHERIES OF THE MIDDLE ATLANTIC, PROBLEMS IN MANAGING A MULTISPECIES, MULTINATION FISHERY. Jackson Davis. Va. Inst. Marine Sci., Gloucester Point, Va. 23062 Until 1966 the U. S. had fished in the Middle

Until 1966 the U. S. had fished in the Middle Atlantic Bight essentially without foreign competition. First the USSR, then Poland, and more recently, East Germany, West Germany, Japan, Spain, and Bulgaria sent fishing fleets to the area. In an attempt to relieve biologic and economic pressures caused by the additional fishing effort the U. S. entered into bilateral fisheries agreements with the Soviet Union in 1967 and with Poland in 1968.

Unfettered fishing by nations not party to the agreements threatens the conservation and economic benefits which otherwise might accrue. Additional problems stem from the differing fishing strategies of distant water fleets and near-shore fleets, from the common property concept of fisheries resources, including anadromous resources, and from differences in political and economic philosophies.

SPERMATHECAL ULTRASTRUCTURE IN THE NEWT. <u>James Dent.</u> Dept. of Biology, University of Virginia, Charlottesville, Va. 22903.

When viewed in thin section under the electron microscope the spermathecal wall of the newt was found to consist of two layers of cells, a continuous inner or lining layer of epithelial cells and an outer myoepithelial layer. The myoepithelial layer is penetrated by occasional openings or intercellular spaces through which the epithelial cells make contact with a basal lamella that bounds the whole tubule. The myoepithelial cells resemble smooth cells having prominent coated pits, dense bodies and fibers that are probably constituted of actin. They are sparsely supplied with mitochondria, ribosomes, golgi and, sometimes, particles of glycogen. Typically the epithelial cells contain secretory granules, numerous mitochondria and ribosomes. They contain some fibers similar to those of the myoepithelial cells but with diameters significantly larger. Occasional golgi profiles are evident and glycogen particles are distributed abundantly throughout their cytosomes in spermathecae of normal adult animals.

A STUDY OF THE REPRODUCTIVE BIOLOGY OF THE SEAL SALAMANDER, Desmognathus monticola, IN BEDFORD COUNTY, VIRGINIA.

Fargaret L. Duncan*and J. J. Thaxton, Jr. (Mrs.), Liberty High School, Bedford, Virginia. 24523

Although several specialists have concluded that Desmognation.

Although several specialists have concluded that Desmognathus monticola have a biennial reproductive cycle, a reevaluation of the reproductive biology of this species is undertaken in this research.

A re-examination of the reproductive biology of the salamander <u>D. monticola</u> as located on the eastern slope of the Elue Ridge Yountains in western Bedford County, Virginia, suggests that year-round activity occurs in the aquatic habitats of this species. An examination of feeding habits indicated that winter feeding did occur. Since winter activity correlates with winter food uptake, and the ratio of food intake to egg production did not decline, year-round breeding is not an unexpected phenomenon.

Evidence collected suggests that the females of <u>Desmognathus</u> monticola deposited eggs in each month in which collections were made. Hatching and development were also found to occur in every month of the year.

occur in every month of the year.

It is suggested that Desmognathus monticola has a reproductive cycle during any season of the year.

THE RESPONSE OF THE MONGOLIAN GERBIL, Meriones unguiculatus, TO AFLATOXIN B1. \underline{J} . \underline{S} . \underline{Dunkin} and G. C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

Adult male gerbils were fed pure Aflatoxin $\rm B_1$ in their drinking water, 10 micrograms/ml, for periods up to 30 days. The animals showed no significant change in body weight, but $\rm H_{20}$ consumption dropped 38%. Upon sacrifice none of the animals had visible gross pathological changes in the liver or kidneys. Oral concentrations ranged from 0.79 to 3.61 mg/kg body weight with no lethality.

Adult males and females were injected with Dimethylformamide (DMF) to determine sensitivity and use as a solvent for the toxin. There were no lethalities, gross pathological changes or weight changes for amounts up to 0.2 cc of DMF/animal.

Aflatoxin $\rm B_1$ dissolved in DMF was injected in adult gerbils in concentrations from 1 mg/kg to 8 mg/kg body weight. The $\rm LD_{50}$ for aflatoxin $\rm B_1$ in adult gerbils when injected in DMF was 4 to 5 mg/kg body weight.

RELATIONSHIP OF COMMERCIALLY CUT PINUS TAEDA TO MARKET-ABLE BOARD FOOTAGE IN A COASTAL PLAIN FOREST. Robert J. Edwards. Dept. of Biology, Christopher Newport Col. Newport News, Va. 23606.

The mean annual growth rate and its relationship to

The mean annual growth rate and its relationship to marketable volume (International kinch rule) was determined using random samples of felled Pinus taeda in Newport News, Va. The number of years necessary to add 2 inch increments to the radius, the average age of the sampled trees, and the growth trends for the tract were also determined.

THE ROLE OF NATURAL HISTORY MUSEUMS IN MODERN BIOLOGY.

h.G. Emsley. Dept. of Biology, George Mason College of the Univ. of Va., Fairfax, Va. 22030.

In contemporary society the Natural History Museum has two primary functions: public education and the curation of collections. Research in systematics is draining their capacity to perform either of these functions satisfactor-Museum directors should re-order their priorities and place qualified personnel in command of educational programs and hire sub-professional curators to conserve existing collections and make them available to systematists working in universities and colleges.

Museums should exchange material on indefinite loan so taxonomic groups are concentrated in single locations where they are under the control of a retired taxonomist of proven competence in that group of organisms. The current political situation precludes the inclusion of tropical countries in the material exchange plan. All material should be identified by the Taxonomic Center for the group to which it belongs or by its delegated specialist.

A PRELIMINARY STUDY OF THE EFFECT OF AFLATOXIN B, ON INTESTINAL PERISTALSIS. <u>Sheryl I. Goldberg</u>, T. Daniel Kimbrough, and Gerald C. Llewellyn. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

This was an introductory study to evaluate the effects of pure aflatoxin B₁, concentrations ranging from 0.0917 micrograms/ml to 1.600 micrograms/ml on duodenal strips taken from juvenile male hamsters. Polygraph recordings using a transducer to measure the changes in gut motility (in vitro) provided the data, and each animal also served as own control.

Hamsters were chosen over the rat because preliminary work indicated that the hamster had a more regular peristaltic pattern, and the gerbil with the most regular pattern was not used because the hamster appeared to have a greater potential for carcinogenic response to aflatoxin and

Measurements made utilized contractions/minute, area under the peaks/minute, and high peak means. Each record made utilized all of these parameters for measurement.

For hamsters, the mean maximum area under the peaks (20.70 cm²/minute) occurred at a concentration of 0.4444 micrograms/ml.

Both the areas under the peaks and the high peak means generally followed the shape of a bell curve. There was no significant change in the number of contractions/minute but, the pattern did change.

THE EFFECT OF GA-3 ON THE HIGH ENERGY PHOSPHATE LEVELS OF THE THREE YOUNGEST INTERNODES OF PROGRESS NUMBER (9 DWARF PEA. D.A. Goodwin* and E. Wilson. Dept. of Biology, Va. State College, Petersburg, Va. 23803

High energy phosphate levels in the upper three internodes of a dwarf pea plant, variety Progress number nine, were found to increase as the result of Gibberellic acid treatment. Untreated dwarf and treated and untreated talls (variety Alaska) were not so effected. High energy phosphate levels were measured in hot water extracts of intermodes by recording the light produced sixty seconds after the-addition of an extract of dried firefly tails. The results indicate that six hours after treatment with the hormome, the dwarf pea internodes showed a significant increase in high energy phosphate levels over controls.

EXTERNAL BETA RADIATION AS AN INHIBITOR OF ALLOGENIC SKIN TRANSPLANT REJECTION IN MICE. Margaret A. Gordon, Dept. of Biology, Madison Col., Harrisonburg, Va. 22801

Single pinch grafts from F₁ (CBA X C57BI/6) female donor mice were applied to C57BI/6 recipients of both sexes. In

the preliminary comparison of graft persistence in four groups of six animals each, grafts held in place with a 32P impregnated bandage, emitting an average dose rate of 25 rads/day, persisted twice as long as untreated controls and significantly longer than donations from mice x-rayed with 400 and 800 R the day before transplant.

In a continued study using only 32P impregnation of round curad bandages (held in place with plastic surgical tape, #1525, "Blenderm", Minnesota Mining and Manufacturing Co.), eighteen allogenic grafts were maintained for over three weeks. As long as bandages delivering a dose of 25 rads/day were kept tightly in place, grafts were not rejected. These animals are being maintained in order to note any long range effects of such a beta radiation dose.

It is postulated that constant low level beta radiation destroys recipient lymphocytes as they migrate into the area of the transplant. It is also possible that low level beta radiation used locally in conjunction with X-radiation or other techniques reported in the literature will prove better than either technique employed alone.

SOME ASPECTS OF POPULATION MANAGEMENT OF PHYTOPHAGOUS MITES ON APPLE AND RELATIVE EFFECTIVENESS OF SOME ACARICIDES. Clarence H. Hill, and Robert A. Cather*. Dept. of Entomology, Va. Poly. Inst. & State Univ., Winchester Fruit Res. Lab., Winchester, Va. 22601.

Much effort has been exerted to devise suitable programs for management of phytophagous mite populations on apple. Several species are involved, but in Virginia the European red mite, Panonychus ulmi (Koch), Schoene spider mite, Tetranychus schoenei McGregor, and the two-spotted spider mite, Tetranychus urticae (Koch) are responsible for most of the damage.

These mites have been able to develop resistance to one acaricide after another. Many formerly effective materials have become obsolete due to developed resistance. Pre-bloom application of petroleum derivatives, superior spray oils, is one of the most appropriate ways to start the season. Afterwards allow low level populations to continue undisturbed. Select pesticides for disease and insect control that are the least offensive to the predators of mites. Alternate row spraying and reducing pesticide rates to bare minimums tends to further reduce the damage to beneficial species. When acaricides become imperative, select one for least injury to predators and use at minimum effective rate.

The currently registered acaricides, in intended, descending order of effectiveness are: chlorphenamidine, Omite, Plictran, chloropropylate, dicofol, binapacryl, Morestan, dinocap, tetradifon and ovex.

OBSERVATIONS ON THE POPULATION ECOLOGY OF THE CAVERNICOLOUS AMPHIPOD CRUSTACEAN CRANGONYX ANTENNATUS PACKARD. J. R. Holsinger* and C. H. Holsinger*. Dept. of Biology, Dominion Univ., Norfolk, Va. 23508.

Observations on a population of the troglobitic amphipod Crangonyx antennatus were made in Molly Wagle Cave, Lee Co., Virginia from Aug. 1967 to Oct. 1970. Nine samples were taken at approximate seasonal intervals and analyzed statistically. From these data it was concluded that the population structure remains relatively constant and is without appreciable seasonal changes. On the basis of size and secondary sex characters, 5 age classes (juveniles, immature males and females, mature males and females) were established. Juveniles and mature females occurred less frequently; the other classes occurred more frequently with immature females being the most frequent. Ovigerous females were seen in the cave during each season but always in very small numbers in one restricted part of the pool area.

It is apparent that there is a selective recruitment of females for breeding, therefore allowing only a few broods to be produced at a time. Selective recruitment would assure a restricted population size and would also account for the low frequency of juveniles. For animals living in a foodpoor environment, like a cave, rigid population control such as that found in Molly Wagle Cave would be a selective advantage. (Aided by NSF grant GY-7498 and the Old Dominion Univ. Education Foundation.)

SCANNING ELECTRON MICROSCOPE STUDIES OF SENSORY ORGANS OF THE TICK GENUS $\underline{\text{IXODES}}$. $\underline{\text{Paul J. Homsher}}$ and D.E. Sonenshine. Dept. of Biology, Old Dominion Univ., Norfolk, Va.23508.

Scanning electron microscopy has many applications in biology one of which is the identification of new characters for taxonomic use. We have been examining the fourth article and Haller's Organ of four species of the tick genus Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. Ixodes (viz., I. boliviensis, I. luciae, I. cookei and I. examinsher. Distinct similarities were noted in certain features and differences in others for each organ. Those characters examined were the number, location and shape of the setae of the Haller's Organ and other surface features associated with it.

HOST-PARASITE INTERRELATIONSHIP OF PLASMODIUM BERGHEI AND TRYPANOSOMA DUTTONI (IN VIVO) IN THE SWISS ALBINO MOUSE. Melvin A. Jacob, Lynchburg College, Lynchburg, Virginia 24504

Plasmodium berghi and Trypansosoma duttoni were injected into separate Swiss Albino laboratory mice. The effect of the blood parasite upon the host, the Swiss Albino mice, was observed for twenty days by taking blood smears every other day. After twelve days, the parasite was reinjected intraperitoneally into new hosts to observe the effect which the parasite had on a second group of hosts. Two mice were infected with both Plasmodium berghei and Trypanosoma duttoni to observe the relationship of both parasites on one host.

RELATIONSHIPS BETWEEN REPRODUCTIVE ACTIVITY AND PARENTAL AGE IN A SEXUAL RACE OF DUGESIA DOROTOCEPHALA. Marie M. Jenkins, Dept. of Biology, Madison Col., Harrisonburg, Va. 22801

Cocoon deposition and production of offspring were studied

Cocoon deposition and production of offspring were studied in sexually reproducing <u>Dugesia</u> <u>dorotocephala</u> during the lifetime of the individuals. Cocoon production began when the planarians were 3-6 months of age and was continuous thereafter, without seasonal interruption, for approximately three years. Highest fertility occurred during the last three months of the first year of life, A gradual decline occurred during the third year and was followed by the complete cessation of offspring production during the fourth year. Significantly fewer offspring were produced by second generation inbred groups than by either first generation inbred or by first or second generation crossbred. Mortality, among both adults and juveniles, was higher in inbred groups than in crossbred. The combination of high mortality and low fertility in inbred planarians points to the possible presence of lethal genes which may act either before or after the planarian emerges from the cocoon.

Approximately one-half the animals fissioned before becoming sexually mature. Fertility was significantly higher in these animals than in those which did not undergo fission prior to becoming sexual. No sexual animals fissioned. Evidence indicates that fission is not a reproductive process in the sexual race but that it is of value in enhancing vigor. (Aided by a Sigma-Xi RESA grant and NIH Grant # HD-02217.)

OBSERVATIONS ON A CAPTURED ENVIRONMENTALLY ADAPTED MONSTER AMPHIBIAN (BUFO SP.) Howard G. Johnston,* Eric L. Morgan, Thomas M. Louis and Robert A. Paterson. Dept. of Biol., V.P.I. & S.U. Blacksburg. Va. 24061.

V.P.I. & S.U., Blacksburg, Va. 24061.

A mature female toad (Bufo woodhouse fowler) with two major abnormalities was discovered September 1968, approximately 40 miles north of Roanoke in Botetourt County, Va.

Radiography of a fifth appendage extending approximately one cm. laterally and one cm. anteriorly form the ventral surface of the pectoral girdle shows two calcified jointed bones at right angles to each other. This non-articulate limb has no digits and its function, if any, is obscure. Eyes are absent and the eyelids are fused. It is also of interest that the development of the ectodermally derived eyes occurs at a much earlier stage in the development of the embryo than does the development in the mesodermally derived limbs.

This unusual toad was found in the wild, fully grown, which implies that she was quite able to adjust to her environment in light of the difficulties resulting from the lack of eyes and an extra appendage.

A SIMULATED NATURAL HABITAT FOR RACCOONS. COLOR MOVIE II Cornelis Laban. Dept. Biology, Richard Bland College, Fetersburg, Virginia 23803

This research is part of a general plan for the development of a science of comparative sociology, as proposed by J. P. Scott. The specific objectives of the study are to develop a method by which functional units of behavior (behavior patterns) can be systematically recorded and described. It is obvious that this cannot be accomplished by observations on behavior as expressed in the natural habitat. One solution to this problem is the development and use of a "Simulated Natural Habitat", or field laboratory. Under the conditions of a standard environment it became possible to describe and quantify behavior patterns in an enclosure which contained as many features as possible of the area in which the free-ranging raccoons were caught.

The observations thus recorded are assumed to be a meaningful record of behavior and are expected to reflect in part the spontaneous repertory of behavior. The simulated habitat contained only a few of the most essential features of a typical raccoon environment in the early stages of the study, hence, only an approximation of the complete repertory of the behavior of free-ranging raccoons was expected to occur in this simulated habitat.

Supported by a NIH Postdoctoral Research Fell'p.

A BEHAVIORAL AND HISTOLOGICAL STUDY OF THE EFFECTS OF DOM (STP) (2.5, DIMETHOXY - 4 - METHYL AMPHETAMINE) ON THE TOBACCO HORN-WORM MOTH MANDUCA SEXTA. Thomas M. Louis and Harriston R. Steeves * III. Biol. Dept., VPI & SU.

The hallucinogen 2, 5,-dimthoxy-4-methylamphetamine, also known as STP, caused histophathologic lesions in the optic ganglion of Manduca sexta. The unchanged compound was recovered from the optic ganglion approximately 8 hours following DOM administration. The optic ganglion accumulated a high percentage of DOM administered. Behavioral effects lasted for approximately 5 hours. (Res. Approved by Joint FDA-PHS Psychotomimetic Agents Advisory Committee - Notice of Claimed Investigational Exemption for a New Drug Dom, IND. 6708)

FURTHER STUDIES OF THE VARIATION IN SERUM CONSTITUENTS OF THE BLUE CRAB CALLINECTES SAPIDUS, RATHBUN. $\underline{M},\underline{P}$. \underline{Lynch} , K.L. Webb and W.A. Van Engel, Va. Inst. of Marine Science, Gloucester Point, Va. 23062.

Serum chloride ($C\ell$), protein(Pr), glucose(G), ninhydrin positive substances(NPS) and total osmotic concentration(Osm) were determined in samples of blood from the Blue Crab, Callinectes sapidus, collected at various locations and times from Va. waters. Monthly samples of crabs were collected from the York Spit area, lower Chesapeake Bay from Feb.'69 -Mar. '71. A cyclic seasonal variation in mean Cl was found. Mean Cl varied from 446-471 meg/l in the winter months to 323-343 meq/l in the summer months. Mean $C\ell$ was more highly correlated with temperature (r=0.72) than with salinity (r=0.10). Mean Osm (measured since June'70) followed the same trend as mean Cl, varying from a low of 779 milliosmols in the summer to a high of 1032 milliosmols in the winter. Mean Pr, G and NPS did not exhibit obvious seasonal trends. Distinct year class (VC) differences were found in mean Pt in female crabs. Older VC ('67 vs '68 VC in '69, and '68 vs '69 VC in '70) had significantly higher mean Pr in six of the seven months in which more than one VC crab was taken.

Crabs were also sampled along a salinity gradient (0.9-30.6 °/oo) during summer and early fall months. Crabs exhibited hyperionic regulation with respect to ${\it C\ell}$ below about 250/00 and hypoionic regulation above this point. Hyperosmotic regulation was exhibited below 250/00 and isosmotic regulation above this point. Ph. NPS and G levels did not appear to be related to salinity.

and Joseph Torres*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185 Oxygen levels equaling and exceeding air saturation of water are believed to be less favorable to the survival of

TOXICITY OF OXYGEN TO MARINE INVERTEBRATES. C. P. Mangum

many invertebrates typically living in low p02 environments. Due to the scanty volume of work on the subject the possibly lethal effects of high pO_2 's have been reinvestigated. Out of 8 species tested only 2 shared clear cut effects. The anthezoan <u>Haliplanella</u> <u>luciae</u> showed significant lethal effects, and the scyphozoan polyp Aurelia auretia exhibited impaired setting ability.

CORRELATION OF THE MORPHOMETRIC VARIATION IN THE EASTERN RACE OF CLINOSTOMUS FUNDULOIDES FUNDULOIDES GIRARD (CYPRINIDAE) WITH TWO SUSPECTED STREAM PIRACIES IN VIRGINIA. Michael T. Masnik. Dept. of Biology, Va. Polytechnic Inst. and State Univ.

Collections of <u>Clinostomus funduloides funduloides</u> Girard from 55 localities in Virginia have been analyzed for 13 morphometric characters. Collections were grouped by drainages and portions of drainages. The majority of fishes were collected near the sites of two suspected stream piracies in Floyd County, Va. The piracies involve the New and Dan Rivers near Meadows of Dan, Va. and the New, South Fork of the Roanoke, and Blackwater Rivers near Adney Gap, Va. Standard statistical and taxiometric analyses of the results reveal clinal evidence supporting the suspected piracies. A product moment correlation coefficient testing meristic counts versus altitude has shown no correlation. In addition the range of variation in morphometric counts for C. f. funduloides in Va. has been noted.

DISTRIBUTIONAL ASPECTS OF AQUATIC COLEOPTERA IN THE DISMAL SWAMP. James F. Matta. Biology Dept., Old Dominion Univ., Va. 23508.

There are 45 species of aquatic coleoptera, representing 4 families, recorded from the Dismal Swamp. The woodland pools, which may be considered to make up the vast majority of the aquatic situations in the swamp, exhibit a rather restricted fauna with only 16 species represented of which Hydrochara obtusatus, Hydaticus bimarginatus, Agabetes acuductus, Agabus punctatus, Thermonectus basillaris, T. ornaticollis, and Bidessonotus pulicarius are the most abundant. Lake Drummond is practically barren of aquatic beetles, having only one species, <u>Hydrophilus triangularis</u> recorded from it. The extremely acid ditches, such as Jerico Ditch are also severely limited in coleopteran fauna, with only 6 species recorded, and only one of these, Hydroporous lobatus at all abundant, while the non-acid ditches show a more diverse fauna. The majority of the 45 species recorded from the swamp were collected from limited or atypical aquatic situations such as roadside puddles, small ponds or a willow swamp.

The faunal associations of the swamp's aquatic coleoptera do not appear to be different from those in other Tidewater areas, and it would be quite difficult to make a case for a separate origin of the aquatic coleoptera of the Dismal Swamp The most striking characteristic of the swamp's aquatic coleopteran fauna is the severe limitation on the number of

A STUDY OF THE FFFECTS OF SELECTED ENVIRONMENTAL FACTORS ON THE GROWTH RATE OF MYTILUS EDULIS. C. E. Mitchell*, Dr. G. F. Levy. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508.

A study was conducted to ascertain the effects of various naturally occuring environmental parameters on the growth rate of the blue mussel - Mytilus edulis. This study was conducted at four sites over a five week period during the summer of 1970. Parameters found to be most influential included the content of oxidizable organic matter in seawater samples and light penetration at the sites. These criteria were used to construct an empirical formula for predicting growth rate.

EFFECTS OF THIOCAYANATE AND L-THYROXINE ON FEMUR RETENTION OF 45-CALCIUM IN MATURE MALE COTURNIX QUAIL ACCLIMATED AT 20° AND 35°C. Eric L. Morgan, Thomas M. Louis, and RobertA. Paterson, Dept. of Biol., V.P.I. & S.U., Blacksburg, Va. 24061

The per cent retention in femur of a single dose of 45calcium was determined in nine month old male Coturnix quail subjected to interacting temperatures and thyroid treatments Coturnix acclimated at 20° and 35° \pm 1°C and then exposed to throcyanate (as 0.1% of diet), L-thyroxine (20ug/100g body weight injected daily), and control thyroidal treatments were tested under laboratory conditions during February and March, 1971. Thyroidal response to experimental treatments was monitored by 131-iodine turnover rates. Quail maintained at 20°C were found to have a greater turnover rate than the 35°C group. Effectiveness of thyroidal treatments was shown by the L-thyroxine groups retaining greater levels while the thiocyanate groups lower levels of 131-iodine compared to controls.

A considerably higher retention of 45-calcium was found in all thyroidal treatment groups maintained at 35°C than at 20°C (P <.025). Thyroidal treatments had no significant effect on femur retention of administered 45-calcium at either acclimation temperature.

VARIATION OF OXYGEN CONSUMPTION WITH TEMPERATURE AND OXYGEN LEVEL IN POLYPS OF AURELIA AURITA AND CHRYSAORA QUINQUECIRRIA. M. J. Oakes and C. P. Mangum. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Oxygen consumption data on <u>C. quinquecirrha</u> polyps exposed to acute temperature changes show general conformity to the Van't Hoff rule with an exception of the \mathbf{Q}_{10} value for the 12.0 to 17.00C interval. <u>A. aurita gives \mathbf{Q}_{10} values larger than predicted by the Van't Hoff rule. Evidence for metabolic acclimation to temperature change is scanty.</u>

In response to a changing oxygen environment, both the strobilating and non-strobilating polyps of A. aurita and C. quinquecirrha are oxy-conformers or partial oxy-regulators in that oxygen concentration influences oxygen consumption at all Pop levels.

SALINITY AND TEMPERATURE EFFECTS ON SETTING PLANULAE OF CHESAPEAKE BAY JELLYFISH. <u>Janet</u> <u>Olmon</u> and K. L. Webb. Va. Institute of Marine Science, Gloucester Pt., Va. 23062 Experiments were designed to test the effects of

Experiments were designed to test the effects of salinity and temperature on setting of planula larvae and development of polyps of the jellyfish Cyanea capillata, Aurelia aurita and Chrysaora quinquecirtha, which are abundant in the Chesapeake Bay. In Cyanea, a winter jellyfish, setting of planulae and formation of larval cysts occurred at 5-45 ppt and at temperatures of 5-25°C; polyps developed at 10-35 ppt and at 5-15°C. Larval cyst formation, once begun, was largely completed within three days, and polyps appeared as early as three days after cyst formation. Polyps of Aurelia, a summer jellyfish, developed at 10-35 ppt and at 15°, 20° and 25°C, though development was slower at 15° than at 25°. Another summer jellyfish, Chrysaora, produced polyps within 5 days at all salinities tested, 8-28 ppt, and at temperatures of 20° and 25°C. About three times as many polyps developed at 25°C as compared to that at 20°C.

The degree of crowding of planulae affected polyp

The degree of crowding of planulae affected polyp development. Optimum concentrations for good polyp development were 2-10 planulae per ml of water for all three species. (Supported by Public Law 89-720, Jellyfish Act.)

ENTOCYTHERID OSTRACODS OF THE LOWER JAMES-YORK PENINSULA, VIRGINIA. Daniel J. Peters, Dept. of Biology, Christopher Newport Col., Newport News, Va. 23606

The four crayfishes known to inhabit the James-York and

The four crayfishes known to inhabit the James-York and the Gloucester-Mathews peninsulas are hosts of six species of entocytherid ostracods belonging to five genera. The burrower, <u>Cambarus d. diogenes</u>, harbors three species (<u>Dactylocythere jeanae</u>, <u>Okriocythere cheia</u> and <u>Ornithocythere waltonae</u>) while the stream-dweller, <u>C. acuminatus</u>, hosts two (<u>Dactylocythere suteri</u> and <u>Donnaldsoncythere ileata</u>). <u>Fallicambarus uhleri</u> and <u>Procambarus a. acutus</u>, sluggish stream, ditch and pond dwellers, both serve as hosts to a single ostracod (<u>Ankylocythere tiphophila</u>). The ecological relationships and the ranges of the ostracods and their hosts are discussed.

BIOLOGY OF THE CEROPIASTES OF VIRGINIA. <u>Dale K. Pollet*</u>, John A. Weidhaas, Jr.*, and Michael Kosztarab. <u>Department</u> of Entomology, V.P.I. & S. U., Blacksburg, Virginia 24061. Since 1948 the distribution of <u>Ceroplastes</u> in Virginia

Since 1948 the distribution of Ceroplastes in Virginia has gradually increased, and now approximately one-third of the state is infested. It has become a pest of both homeowner and nurserymen. Three species, Ceroplastes ceriferus Anderson (Mexican wax scale), Ceroplastes sinensis Del Guercio (Chinese wax scale), and Ceroplastes floridensis Comstock (Florida wax scale) have been collected in the state with only the first two species having established infestations. All species are parthenogenic and have four instars. Ceroplastes ceriferus is the predominent species and has a host range which includes 40 families of plants. The parasite Coccophagus fraternus How, has been reared from all species and the predator Laetilia coccidivora (Comstock) has been reared from the two species with established infestations.

THE PRODUCTION OF AFLATOXINS BY <u>Aspergillus</u> flavus ON BLACK SUNFLOWER SEED MEDIA, <u>J. F. Quensen</u> and G. C. Llewellyn. Va. Commonwealth Univ., Dept. of Biology and C. E. O'Rear, Va. Dept. of Agriculture and Commerce, Food and Drug Section, Richmond, Va. 23220

Aflatoxins have been reported as fungal metabolities of Aspergillus flavus in such substrates as peanuts, corn, cotton seeds, coconuts, and rice.

Aflatoxin content of samples of commercial black sun-

Aflatoxin content of samples of commercial black sunflower seeds was determined to be 2ppb (negative). The seed used contained 1.76% inert matter, 0.30% other seeds, and 9% nonviable sunflower seeds.

Cultures of sunflower seeds and sterile water were made to determine the natural fungal flora of the seeds. These resulted in the growth of several $\underline{\text{Rhizopus}}\ \underline{\text{spp}}.$ when cultured at 27±3°C. Cultures of crushed seeds resulted in more rapid growth and greater quantities of these dominant fungi. Neither crushed nor whole seed cultures tested were positive for Aflatoxin ($\boldsymbol{<}$ 2ppb).

Individual cultures of crushed and of whole seeds were inoculated with A. flavus, (ATCC-15548), and produced aflatoxin. Crushed seed cultures produced B1, B2, G1 and G2 with a mean total aflatoxin content of 4,065.8 ugm/culture after 25 days of growth. Whole seed cultures lacked B2 and contained a total mean aflatoxin content of 3,057.1 ugm/culture. The absence of B2 did not account significantly for the appreciable difference in the total aflatoxin values. (Assisted by Thomas Eadie Mycotoxin Laboratory, VDA&C)

DIPTERA ASSOCIATED WITH GALLS ON ELMS (ULMUS SPP.). Wm. H Robinson*. Dept. Entomology, Va. Polytechnic Inst., Blacksburg, Va. 24061

There are numerous insects associated with leaf galls on Ulmus rubra and Ulmus americana. The Diptera found with these galls include species in the families: Syrphidae, Phoridae, and Chamaemyidae. The immature stages of species in these families are found within the gall.

COCKROACH MUTANTS OF SPECIAL INTEREST, PARTICULARLY IN THE AREA OF REPRODUCTIVE BIOLOGY. $\underline{M_*, H_*, Ross}$, Dept. of Entomology, Va. Polytechnic Inst. and St. Univ. Blacksburg 24061.

Certain mutants of the German cockroach show changes from wild-type in characteristics affecting reproduction. Hatch data reveal some such differences. Examples of hatch reduction involving lethality are given. In another case, small progeny nos. produced by shriveled wing females are partially due to a reduced no. of eggs/ootheca. Apparently, some oocytes fail to mature fully and are not oviposited in the initial ootheca. Hatch data for pale-body (Pb) indicate that females, mated with Pb males, also fail to deposit the expected no. of eggs. The mutant males appear to lack some capability possessed by wild-type males to stimulate complete oviposition and/or to prevent resorption of some eggs, such as seen in virgin wild-type females. In addition, there is a tendency to include unusual numbers of unfertilized eggs in the oothecae from \underline{Pb} male matings. \underline{Pb} males lack sexual competitiveness but, once mated, coupling time is significantly longer than that of wild type. In the curlywing mutant, females are sterile and rarely produce oothecae. The ovaries seldom mature beyond the stage found in large nymphs. Experiments are discussed which suggest the females lack a sex attractant, but that mating can be induced. Mated females show ovarian growth but oothecae are deformed and sterile. This capability of the male to stimulate ovarian growth has not been suspected for this species since oviposition occurs in virgin females.

TEMPERATURE SENSITIVITY OF OXYGEN CONSUMPTION OF LATITUDINALLY SEPARATED POPULATIONS OF UROSALPINX CINEREA (PROSOBRANCHIA: MURICIDAE). J. Malcolm Shick* and C. P. Mangum. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

Although the oyster drill $\underline{\text{Urosalpinx}}$ $\underline{\text{cinerea}}$ is often cited as an example of a species that has formed physiological races among populations experiencing different thermal conditions, temperature effects on the respiratory metabolism of these organisms have not been studied. Acclimated metabolism-temperature curves were constructed for four latitudinally separated populations that include two subspecies. Virginia \underline{U} . $\underline{cinerea}$ $\underline{follyensis}$, and Massachusetts and Maine <u>U. cinerea cinerea</u>, exhibit the classical pattern of latitudinal compensation of oxygen consumption, apparently due to an inverse size-latitude relationship that is contrary to Bergmann's rule. It is suggested that this anomaly may have resulted from the selective development of a smaller maximum size in the northern populations, although transportation by man along the Atlantic coast has probably confused the situation. For reasons not immediately apparent, the Massachusetts animals show rates consistently lower than those of the North Carolina, Virginia, and Maine animals.

INDICES OF STRESS IN CROWDED POPULATIONS OF HOUSE MICE AND WHITE MICE. J. E. SKEEN, R. H. Gilas Jr.*, and H. S. Masby. Division of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ. Blacksburg. Va. 24061

Inst. and State Univ., Blacksburg, Va. 24061
White mice and house mice were weighed and caged after 2 weeks of isolation at densities ranging from one to-six for 4 weeks. Half of the groups were fed a restricted diet and half ad libitum. Each density group at each level of nutrition was replicated three times. During the experiment, activity, aggrassion, and hierarchy were studied for the ad libitum groups. At the end of 4 weeks, an endotoxin challenge was administered to each animal (Thompson, J. A. 1971. Responses of several mouse populations to endotoxin challenge. Va. Acad. Sci., Blacksburg, Va. May 1971). Surviving mice were sacrificed with ether; reweighed; their volume taken; and their adrenals, spleen, seminal vasicles and preputials removed and weighed. Apparent wounds were used as an index to the physical condition of the animals.

The weights of the seminal vesicles were found to decrease with increasing density and appeared to be the most consistent index to density stress of the variables studied. The seminal vesicle weight, preputial weight, body weight, and body volume were significantly related to density at the 0.01 level and the activity index at the 0.05 level. The adrenal and spleen weights were not significantly related to density at the 0.05 level. Hierarchial position was significantly related to the physical condition of the animal at the 0.01 level, and not to the adrenal or preputial weights (0.05).

THE USE OF RADIOISOTOPES AS AN AID IN ECOLOGICAL STUDIES ON TICK VECTORS OF DISEASE. A SUMMARY OF THREE YEARS OF DEFINITIVE FIELD STUDIES IN VIRGINIA. D. E. Sonenshine. Dept. of Riology. Old Dominion University. Norfolk. Va. 23508.

Biology, Old Dominion University, Norfolk, Va. 23508.

Laboratory reared larvae of the American dog tick Dermacentor variabilis (Say) tagged with 14C glucose were released and recaptured in a study area near Montpelier, Va. by live capture of their small mammal hosts. These individuals were distinguished from native larvae with a gas flow end window detector. The systematic release and subsequent recapture of these larvae provided data which revealed knowledge of the ecology of this tick that could not have been obtained by other means. Specifically, knowledge was gained of overwinter survival, population size, dispersal in the natural habitat, and the proportion of individuals which find hosts. Utilizing these data and other data on other life stages, a model of the American dog tick population has been constructed which predicts the numbers of each life cycle stage that may be expected under the conditions observed in this study area. Data for a 3 year period is currently under study to determine the year to year changes in magnitude of these populations and, if possible, the environmental changes that may have contributed to them.

REPORT OF STUDIES ON THE ECOLOGY OF TICKS INFESTING WILD BIRDS AND RABBITS IN THE VA.-N.C. PIEDMONT (Acarina: Ixodidae). by <u>D.E. Sonenshine</u> and I. J. Stout, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Host parasite relationships and seasonal dynamics of 3

species of ticks infesting birds or rabbits or both at 2 localities in the Piedmont of Va. and N.C. were studied. Cottontail rabbits represented the dominant host for the immatures of Haemaphysalis leporispalustris (Packard) and Ixodes dentatus Max in Va., where both rabbits and birds were examined. Bobwhite quail were almost as important as rabbits as hosts for the immatures of the former but not of the latter tick species. Other bird families of importance as tick hosts included Fringillidae, Mimidae, Troglodytidae, Turdidae and Parulidae. I. brunneus Koch was found primarily on the slate colored Junco, Cardinal, and White-throated Sparrow. Tick burdens on birds at the 2 localities were similar, but were substantially lower than the burdens reported in other areas of the U.S. Host-seeking activity by immatures of the 2 bird-rabbit ticks were bimodal, with peak activity in late summer or fall (dominant period), and again in winter or early spring. The I. dentatus activity peak occurred 1 or 2 months later in the fall than that of $\underline{\text{H.}}$ <u>leporispalustris</u>. Abstract submitted in competition for the $\underline{\text{J.}}$ Shelton Horsley Award.

THE DEVELOPMENT OF THE THERMOREGULATORY ABILITY IN THE JAPANESE QUAIL, COTURNIX COTURNIX JAPONICA, BEFORE AND AFTER HATCHING. D. E. Spiers,* R. A. McNabb,* F. M. A. McNabb,*. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Unincubated eggs of Japanese Quail were implanted with thermocouples, below the shell membrane, to measure egg temperature. Thermocouples also were placed in the rectums of newly hatched quail chicks to measure body temperature. Daily resistance to temperature change was determined up to nine days hatching by placing the quail in a 30°C air-bath. Little development of thermoregulatory ability was present before hatching. Not until four days after hatching did any significant resistance to cooling occur. Complete control of endothermy was not present by nine days after hatching. Histological studies of thyroid development in hatchlings indicate a decrease in follicle cell height three days after hatching. (Aided by a grant from Frank M. Chapman Memorial Fund, American Museum of Natural History).

IN VITRO CULTURE OF BLUE CRAB HEMOCYTES. Melissa Stanley.*
Dept. of Biology, Ceorge Mason College, Fairfax, Va. 22030.

Previous attempts to culture crustacean tissues have met with little success. In establishing a tissue culture method an abundant supply of cells that are known to be undamaged is essential so that variations in the effect of culture conditions may be evaluated with confidence. Hemocytes alone require no physical or enzymatic disaggregation and yet will attach to the substratum permitting optical examination. Previous attempts to use hemocytes of the blue crab, Callinectes sapidus, were thwarted by the extremely rapid and viscous coagulation and melanization of the hemolymph. Anti-coagulants proved of little value but a simple technique relying on massive dilution permits the culture of large numbers of unclotted cells. The hemocytes survive well in modified vertebrate tissue culture medium but cell multiplication has not been demonstrated. Most of the attached cells resemble vertebrate fibroblasts and are not easily referred to the various types of hemocytes. Present efforts are directed toward improving the medium and determining changes in the cell population in vitro.

RECOVERY OF REPRODUCTIVE FUNCTION BY PRAIRIE DEERMICE FROM ASYMPTOTIC POPULATIONS. <u>C. R. Terman</u>. Lab. Endo. & Pop. Ecol. Dept. of Biol., College of William & Mary.

Prairie deermice greater than 100 days of age and nonreproductive in laboratory populations were paired with fertile mates or with other inhibited population animals. Controls were born in our production colony and maintained as mono-sexual groups of ten until paired with fertile mates.

A large percentage of all treatment animals produced young following pairing. The time required for reproduction by population animals paired with proven mates was longer than for controls and shorter than for pairs composed of both population animals. The rates of reproductive recovery did not differ between males and females of the same treatment.

The significantly slower rate of recovery of reproductive function for population pairs than for animals from populations paired with fertile mates suggests that mutual stimulation is involved in recovery and is initially lacking or minimal.

ing or minimal.

The data indicate that a period of physiological and behavioral adjustment following removal from the populations is necessary before reproduction. The mechanisms preventing reproduction within the populations are unknown.

(Supported by NIH grants MH-08289, HD-04787, and Research Career Development Award HD-07391.)

A COMPUTER PROGRAM FOR RANDOMIZING MACROBENTHOS WHEN ESTABLISHING A DIVERSITY INDEX USINC THE SEQUENTIAL COMPARISON TECHNIQUE. Melvin H. Thomas* and George M. Simmons, Jr., Virginia State Water Control Board and Virginia Commonwealth University, respectively.

The program is designed to calculate a diversity index using the sequential comparison technique when similar groups, such as genera or species, are identified by a number and a total count provided for each group. The program generates a linear series of randomized numbers and compares these numbers based on like and unlike species in a fashion similar to the hand-operated method. The computer program removes much of the manual drudgery from this type of analysis of community structure and preserves the specimen intack for later identification purposes.

There is no significant difference between the results obtained by the program and the results obtained by the hand-operated method.

It is possible to do multi-iterations of the index with the program at extremely low cost per iteration.

the program at extremely low cost per iteration.

The program is designed to be used by the non-biologist as well as the biologist for analysing community structure of the macrobenthos when based upon the sequential comparison technique.

RESPONSES OF SEVERAL MOUSE POPULATIONS TO ENDOTOXIN CHAL-LENGE. J. A. THOMPSON*, R. H. Gilas, Jr.*, and H. S. Mosby. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Accurate knowledge of mechanisms by which animal populations are controlled is undoubtedly important to the future of wildlife management. Most mammalian populations are kept within limits set by the environment through density dependent mechanisms such as intraspecific competition for food and space, social behavior, and disease.

House mice and white mice were marked, weighed and caged after 2 weeks of isolation at densities of 1 to 6 for 4 weeks. Half of the groups were fed ad libitum with the remainder fed a restricted diet. At the end of 4 weeks, each mouse was injected intraperitoneally with E. coli endotoxin. All mice were reweighed, their volume taken, and their adrenals, spleens, seminal vesicles, and preputials removed and weighed. Behavioral observations were made during the study to determine levels of aggression and activity.

Increasing population density without restricting nutritional intake resulted in decreasing mortalities associated with endotoxin challenge. Croups on low nutrition had increased mortalities at the higher density levels. White mice were more susceptible to endotoxin than were house mice, especially in the low-nutrition group. All of the indices of stress were influenced to some degree by reduced nutrition levels. The white mice were more noticeably affected than the house mice.

UPTAKE OF SEVERAL AMINO ACIDS BY ISOLATED RAT MITOCHONDRIA, Janice O. Tsokos*, and R. A. Paterson. Dept. of Biology, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061

The ability of isolated rat liver mitochondria to take up L-ornithine, L-lysine, L-arginine and L-citrulline was investigated by a method involving incubation with $^{14}\mathrm{C}$ -labeled amino acid, a subsequent centrifugal separation of the mitochondria, and calculation of matrix concentration of substrate using measured volumes of extra- and intra-mitochondrial pellet spaces.

L-ornithine is concentrated severalfold against the gradient by these mitochondria, in a substrate-saturable process, as expressed in the form of an adsorption isotherm. The uptake of L-lysine and L-arginine parallels that of L-ornithine, at lower accumulation levels. L-citrulline is not accumulated but is taken up to the point of approximate equilibration with low extramitochondrial concentrations, also in a substrate saturable process.

Further studies of the behavior of L-ornithine and L-citrulline in the system, important because of the compartmentation of the urea cycle enzyme L-ornithine carbamoyltransferase in the mitochondria, are reported.

RESISTANCE OF TOXIN AND VECETATIVE CELLS OF <u>CLOSTRIDIUM</u>

<u>BOTULINUM</u> TO HEAT AND CHEMICALS. <u>J. Upadhyay</u>, K. Parvati, and <u>Sueh-ying</u> Chang. Va. State Col., <u>Petersburg</u>, Va. 23803

We have found that the spores of <u>Clostridium</u> <u>botulinum</u>

We have found that the spores of <u>Clostridium</u> <u>botulinum</u> are very resistant to heat and chemicals. However, the heat resistance of vegetative cells and their toxin has not been thoroughly investigated.

The cells were grown in 5% trypticase medium, harvested by centrifugation, washed 3-5 times with distilled water or normal saline and heated at different temperatures or treated with formalin.

About 15-20 gm Swiss Webster mice were injected with 0.2 ml (about 10^6) vegetative cells for toxin assay.

The results indicate that the vegetative cells can withstand heating at 100 C for 20 minutes or more in distilled water. It takes more than 3 hours to kill the cells at 90 C. Heating even for 3-4 hours at 80 C does not significantly reduce the number of vegetative cells.

The vegetative cell toxin is destroyed in about 5 minutes at 65 C. Incubation in formalin also destroys the toxin. Inoculation in 2% formalin for about 2 days or in 4% formalin for 1 day destroys almost all the toxins.

These results indicate that the vegetative cells are more resistant to heat, and that toxin can more easily be destroyed, than is generally understood.

EXPERIMENTAL INTROGRESSION IN THE GENUS PHASEOLUS I. EFFECT OF MATING SYSTEMS ON INTERSPECIFIC GENE FLOW. J.R. Wall. Dept. of Biology, George Mason College of the Univ. of Va., Fairfax, Va. 22030.

An analysis of the effects of three backcross mating

systems upon the introgression of a quantitatively determined morphological character, hypogeal germination, from Phaseolus coccineus into P. vulgaris, an epigeal species, reveals that mating systems have a significant effect upon introgression, particularly in early generations. The mating systems evaluated measured gene flow through (1) male gametes, (2) female gametes, and (3) female gametes when a random sib mating generation was inserted between backcross generations. The interspecific populations were in two instances carried to the BC3 and in one instance to

the BC₂.

The results demonstrate that mating systems significantly affect gene flow between partially isolated diploid species. Of the mating systems tested, sib mating in conjunction with backcrossing appears to achieve the best balance between enhanced heterospecific genome recombination, a prerequisite for introgression, and those deleterious effects of recombination which lead to hybrid breakdown and a disruption of interspecific gene flow.

THE EFFECTS OF DIETARY PROTEIN CONTENT ON WATER CONSUMPTION AND AMMONIA EXCRETION OF THE PIGEON, COLUMBA LIVIA. J. M. Ward, Jr., F. M. A. McNabb, R. A. McNabb. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg,

When ad lib. water (AW) consumption and minimum water (MW) requirements were measured in pigeons on a low (LP) and high (HP) protein diets (approx. 12% and 44% protein, respectively), a significant increase was found in both water consump tion measurements on the high protein diet. On the low protein diet, ad lib. water consumption and minimum water requirements were 8.7 \pm 0.6 and 4.25 \pm 0.2 percent of body weight per day, respectively. The same parameters were 33.3 ± 2.8 and 14.4 ± 1.0 percent of body weight per day on the high protein diet.

Urine was collected with a cloacal cannula and analyzed for ammonia-nitrogen (NH3-N). Means of highest urinary NH3-N concentrations were ranked from lowest to highest (as ${\rm ugN/m1}$): LP-MW, 1457; HP-AW, 1459; LP-AW, 1731; HP-MW, 2088. Means of lowest urinary ammonia concentrations for each bird in the three groups, LP-MW, HP-AW, and LP-AW, were 1/3 - 1/2 the means of highest concentrations. In contrast, the mean of lowest concentrations for the HP-MW group was only 25% less than the mean of highest concentrations.

In summary, elevated dietary protein levels were found to have pronounced effects on both water consumption and ammonia excretion in <u>Columba</u> <u>livia</u>.

VEGETATION COMPOSITION AND DISTRIBUTION ON A BAR-RIER ISLAND OF VIRGINIA'S EASTERN SHORE. William M. Willis and Jaques S. Zaneveld, Inst. of Ocean-ography, Old Dominion Univ., Norfolk, Va. 23508 Four vegetation units may be described for Smith Island: 1) a beach and dune grass community

Smith Island: 1) a beach and dune grass community dominated by Ammophila breviligulata, 2) a marsh community dominated in its coastal portions by Spartina alterniflora, and in its inland portions by S. patens and Distichlis spicata, 3) a forest community dominated by Prunus pennsylvatica and Pinus taeda, and 4) a shrub community dominated by Myrica cerifera.

Distribution of these units is primarily controlled by a tidal immersion period as a function

trolled by a) tidal immersion period as a function of elevation above mean sea level, b) wave exposure, c) salt spray exposure, and d) catastro-phic events such as storms and fires. Overall distribution is undoubtedly controlled by the dom-inant topographic feature of the island---a system of parallel low ridges transversing the island obliquely. These ridges are regarded as originating as ancestral barrier dunes successively deposthe das the island grew in the southwest direction. The forest community occupies the tops of the ridges, while the marsh community occupies the swales between ridges. The shrub community occupies an intermediary position. The dune community is generally restricted to the ocean front.

News a large majority of the raccoon population remains near aquatic habitat with few scattered captures upland. The trapping and distributional data was compared with food consumption of raccoons in the two areas as determined by fecal and gut analysis.

RELATION OF ELEVATION AND SALINITY TO DISTRIBUTION OF CERTAIN SALT MARSH COMMUNITIES. E. Spencer Wise. Dept. of Biology, Christopher Newport Col., Newport News, Va. 23606.

Distribution of high marsh communities in two finger marshes along Broad Bay in Seashore State Park, Virginia Beach, Va. was analyzed in terms of salinity and microelevation. Tidal range was 30 cm, and composite salinity of the substrate in the marshes varied between 3000 and 18,000 ppm in the areas occupied by halophytes. In both marshes of the study <u>Distichlis</u> <u>spicata</u> was found in the widest range of elevations and salinities. <u>Juncus</u> roemerianus was found in pannes or area inunadated for long periods, but over a wide range of salinities, Spartina patens occurred at low elevations, within a narrow range, on sites that were not inundated for long periods. Within each marsh relative salinities and actual elevation and drainage appeared to be the factors affecting zonation.

TRAP MANIFESTED BEHAVIOR AND DISTRIBUTION OF RACCOONS IN TWO NATURAL AREAS OF VIRGINIA AS RELATED TO AVAILABLE FOODS. Elton L. Winslow* and D. E. Sonenshine, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508. A study was undertaken comparing populations of raccoons

(Procyon lotor (L.)) in two natural areas of Virginia, one

bution at both areas was found to be non-random. At Newport

News the animals were found to be concentrated along the

water's edge. At Montpelier two concentration peaks were observed, one along the water's edge, the other at about 800 to 1000 feet from the water's edge. The distributional data suggests that two behaviorally distinct groups are

present within the raccoon population at Montpelier, one remaining near the water's edge, the other roaming farther upland, probably in search of food. In contrast, at Newport

in the Piedmont physiographic province (Montpelier study area) near Richmond, the other in the Coastal plain at Newport News. Comparison of capture data indicated that the capture success per 100 trap nights was higher at Newport News (1.58) than at Montpelier (0.66). However, a similar comparison of recapture success per 100 trap nights indica-ted a much higher recapture incidence at Montpelier (0.33) than at Newport News (0.07). Trap reflected animal distri-

FRESHWATER PROTOZOAN SPECIES OVERLAP IN NATURAL AND

FRESHWATER PROTOZOAN SPECIES OVERLAP IN NATURAL AND ARTIFICIAL SUBSTRATES. William H. Yongue, Jr. and John Cairns, Jr. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

A series of polyurethane sponges were anchored, during the summer of 1970, one foot from the bottom of Douglas Lake, Michigan, in 8 feet of water. Periodically substrates were harvested for protozoan colonizers and diversity and sumbors of species determined. Beathing collections were numbers of species determined. Benthic collections were made by scuba diver. Natural substrate-artificial substrate species overlapswere 76%, 85%, and 82%. These and other results tend to indicate colonization from the benthos and that communities established in polyurethane sponges reflect the native micro-ecosystems.

======THE BENTHIC MARINE ALGAE OF DELAWARE, U.S.A. ======= Jacques S. Zaneveld, Inst. of Oceanography, Old Dominion Univ. The instable habitats of sand along the Delaware sea coast and mixed sand and mud inside the Delaware Bay do not provide adequate substrates for many of the algae that find a holdfast along the rocky shores of New England. Such species are developed on artificial structures, such as the breakwaters. Nevertheless, field studies carried out along the Delaware sea coast and Bay have revealed the presence of 70 different taxa of attached benthic marine algae. Of these species 11 belong to the Cyanophyceae, 21 to the Chlorophyceae, 1 to the Xanthophyceae, 18 to the Phaeophyceae, and 19 to the Rhodophyceae. The majority of these are new records for the state of Delaware. The reproductive periodicities of the species are tabulated, showing that the maximum reproductive periods seem to last from late May through September. The more significant ecological data are discussed and a climograph is added based on observations by the U.S.C.G.S. over a period of 18 years. The species distribution shows that all Delawarean taxa are also present north of Cape May. The southern limit for 17.1 % of the recorded species is the Delaware coast and for 18.6 % it is Cape Hatteras. The remaining 64.3 % are distributed all along the east coast of the United States. The distribution of the algae is seasonal in character; none of the species was found to occur all year round.

Section of Botany

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12—14, 1971, Blacksburg, Virginia

PLANTS OF THE WETLANDS OF MASSANUTTEN MOUNTAIN, Lena Artz, Waterlick, Va. 22661

Compared to the wetlands of coastal plains and other areas, those of the Massanutten area are small. But plants of the Massanutten bogs are interesting from the standpoint of plant geography. These areas range from almost mountain tops to the valley floor and occur intermittently, for a distance of about forty miles out of the fifty-mile length of the range.

A STUDY OF BETA-CAROTENE-PROTEIN BINDING IN CHLOROPLAST LAMELIAR MEMBRANES. M. W. Banschbach* and J. L. Hess. Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State U., Blacksburg, Va. 24061

Knowledge of lipid-protein interactions is crucial to understanding membrane structure and function. Specificity of hydrophobic interactions between lipid and protein was examined in a β -carotene-protein complex from chloroplasts.

A β-carotene-lamellar protein fraction was obtained by sequentially extracting ruptured chloroplasts with 50, 70, 75, and 80% (v/v) acetone:water solutions. Centrifugation of the above fraction on a discontinuous sucrose density gradient yielded a low density β -carotene-protein fraction which floated on 1 M sucrose and contained over 50% of the β-carotene and 5% of the protein placed on the gradient. Pepsin and trypsin proteolysis was used to evaluate the extent of β -carotene-protein interaction. As a control, β carotene was extracted from both fractions with 100% acetone. Unreacted protein was removed and hydrolysis measured as ninhydrin and Folin positive material solubilized. hydrolysis was equally impeded in both fractions, 88% of control; pepsin showed much less ability to hydrolyze the low density fraction, 65% of control, compared to the crude $\beta\text{-carotene}$ protein fraction, 89% of control. Both fractions differ significantly in their amino acid content. Protein in the low density fraction appears to have a high capacity for binding β -carotene although specificity of binding is not yet understood.

AN UNPUBLISHED DIGHTEFNTH CENTURY DESCRIPTION OF THE PINES OF VIRGINIA. Edmund Berkeley. Dept. of Biology, Central Va. Cmnty. Col., Lynchburg,24502 Many students of eighteenth century American botany have found the Bartram Papers of the His-

torical Society of Pennsylvania a valuable source of information. Presumably some of them have been interested in a lengthy account of the Pines of Virginia, in John Bartram's distinctive hand. It is not clear whether this has been assumed to be an original account by Bartram, or one sent to him by someone else. "ecent study establishes that the paper is Bartram's copy of a paper written by Dr. John Mitchell, of Urbanna, Virginia. Evidence is presented to establish Mitchell's authorship, and a surmary of the content of the paper is reported.

SHALE BARREN SPECIES AND SPECIATION. Norlyn L. Biology Dept., Madison College, Harrisonburg, Va. 22801 and Dept. of Botany, Univ. of Md., College Park, Md. 20742.

An endemic flora exists on Devonian and Ordovician shale barrens in the eastern Appalachian regions of Pennsylvania, Maryland, West Virginia, and Virginia. The physiognomy of the barrens is in marked contrast to the major climax asso-ciations in which the barrens are located. The woody vegetation is sparse and dwarfed with no characteristic forest stratification while the herbaceous forms are dispersed with many uncolonized sites. Characteristic and endemic species occurring on the more exposed parts of the barrens number approximately 100 with endemic and near-endemic species accounting for about 20 percent. Broad generalizations have been made regarding the derivation of the endemics. No one generalization can be made which explains the derivation of all shale endemic species, either in time or space. The species are neoendemics, paleoendemics or disjunct endemics. It is suggested that several of the endemics (or their ancestors) moved into the Appalachian barrens by a northern migratory pathway, being forced southward by the advancing glaciers. It could equally be said that at least one endemic, Eriogonum allenii S. Wats., or its ancestoral types, moved eastward along a southern route from the southern end of the Rocky Mountains to the Appalachian

OBSERVATIONS OF GROWTH AND DIVISION OF LIVING PLANT CELLS. Robert T. Brumfield, Longwood College, Farmville, Va.

The development of growing tissues can be recorded by photographic techniques. A camera has been designed to record the growth, division, and maturation of cells in the living roots of small seeded grasses. Preliminary studies indicate that the technique may yield significant data on the control of cell growth, cell division, and cell differentiation.

THE DISTRIBUTION OF LYGODIUM PALMATUM (CLIMBING

FERN) IN VIRGINIA. Dorothy F. Chappell. Prince Edward Academy, Farmville, Va. 23901

Lygodium palmatum, a rare fern, occurs locally in Virginia. Collections have been made in the mountains, on the piedmont, and the coastal plain. The habitat of each population is similar, on moist soil near streams, in dense shade and with little undergrowth. Most populations appear to be small but thriving. The fronds of Lygodium palmatum are at their peak in early fall and the plant is easily recognized throughout the winter.

SUMMER PHYTOPLANKTON IN THE NERITIC WATERS BETWEEN CAPE HATTERAS AND CAPE COD. S. Craft* and H. G. Marshall, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Surface phytoplankton were collected at 32 stations over the continental shelf and slope waters between Cape Cod, Mass. and Cape Hatteras, N. C. Collections were made in August 1969 aboard the research vessel ALBATROSS in the Groundfish Survey Program of the Bureau of Commercial Fisheries of Woods Hole, Mass. This study is part of a long term seasonal investigation of phytoplankton off the eastern coast of the U.S. Highest numbers of phytoplankton were found at the insore stations with the diatoms, in particular, Rhizosolenia alata dominating the population. Several species were ubiquitous including R. alata, Nitzschia closterium, N. pungens atlantica and Leptocylindrus danicus. The total number of pyrrhophyceans was usually low at both inshore and offshore stations with <u>Ceratium tripos</u>, <u>C. macroceros</u> and <u>Exuviella compressa</u> predominate. No definite trend could be established for total phytoplankton increase or decrease in a North-South direction. However, certain species were limited in their North-South distribution. The subtropical species, <u>Climacodium frauenfeldianum</u> and <u>Rhizosolenia calcar avis</u> were most prevalent from Cape Hatteras to 38°28 N indicating possible entry from the Gulf Stream. <u>E. compressa</u>, <u>C. macroceros</u> and <u>C. tripos</u> were not found north of Long Island. Silicoflagellates were represented in low numbers by <u>Dictyocha</u> $\frac{\text{fibula}}{\text{grant GB 13906}}$ and $\frac{\text{Distephanus}}{\text{grant GB 13906}}$ speculum.

THE SIGNIFICANCE OF DISJUNCT DISTRIBUTIONAL PATTERNS IN VIRGINIA. A. M. Harvill, Jr. Dept. of Natural Sciences, Longwood College, Farmville, Va. 23901

Disjunct populations of plants in Virginia record vast migrations and segregations of vegetational types during Wisconsin and postglacial times because of the persistence of some populations in favorable enclaves where edaphic and other ecologic factors compensate for changing climates.

AN ORDINATION OF THE UPLAND FORESTS OF THE VIRGINIA EASTERN SHORE. G. F. Levy. Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Eleven upland forest stands located in Northampton and Accomac counties were studied using a random series of point centered circular nested quadrats. Importance values were computed for each tree species in each stand. Stands were ordinated in two dimentions using the dissimilarity index D = 1- 2W/a+b. Significant species, soil types, percent sand, silt and clay and soil were plotted on the ordination model in an attempt to isolate factor complexes which relate to stand diversity. In addition, geographical relationships such as distances north and south, east and west, from the Chesapeake Bay or the Atlantic Ocean were plotted. An index of disturbance was derived and also plotted.

Though analysis to date are incomplete, it would appear that soils, geographic location and stand history are the most significant factor complexes operating upon the vegetational mosaic. Soils relation principally to water retaining characteristics, geographic location to climate and past history to secondary successional stage. Proximity to the Chesapeake Bay or the Atlantic Ocean no doubt pays an important role in the composition of some lowland community types, but appears to be insignificant in the case of the upland forests of this region. (Aided by ODU Educational Foundation Grant #810.)

A STUDY OF THE VOSENATION IN SO E DISMAL SWARP OPENINGS. Carole C. Lohman*, and G. F. Levy. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508.

A quantitative study of the vegetation occurring in three selected openings in Dismal Swamp was made during the summer of 1970. Herb frequency was determined using twenty .2m random quadrats. The forest edge of each area was sampled using the quarter-point method with five points sampled at each site. Soil samples were analysed for pH, per cent organic matter, water retaining capacity, and texture. Herb relative frequencies were used to compute index of similarity values. For edge vegetation an importance value computed from the sum of relative density and frequency values was obtained for trees and saplings. The most prominent tree species and their importance values were Liquidambar straciflua, 63.7, at site 1; L. straciflua, 43.3, and Acer rubrum, 33, at site 2; and Quercus velutina, 29.7, at site 3. The most prominent saplin species and their importance values were Carpinus caroliniana, 16.5, at site 1; L. stryaciflua, 30.9, and A. rubrum, 13.35, at site 2.

The data obtained appears to be indicative of a change

The data obtained appears to be indicative of a change occurring throughout the Dismal Swamp. The hydric nature expected in a swamp is changing to one of more mesic nature like that found in a mixed hardwood forest. Probable causes for this change include drainage, lumbering activities, and fire. (Supported by N.S.F. U.R.P. grant no. GY-7498.)

PHYTOPLANKTON IN THE TROPICAL SOUTHEASTERN PACIFIC. H. G. Marshall, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 23508.

Phytoplankton and hydrography data were obtained during Stanford Oceanographic Expedition #19 aboard the R/V TE VEGA (August 1968) in southeastern Pacific waters. A vertical series of collections were made at 5 open water stations to 300 meters depth. Additional surface samples were taken within the Galapagos Island complex over a $3\ \mathrm{week}$ period. Highest numbers of phytoplankton and greatest species diversity occurred at open water stations that were under the influence of the Peru Current System. Diatoms and coccolithophores predominated, with Chaetoceros decipiens, Coscinodiscus spp., Rhizosolenia spp. major diatom species, with the coccolithophore <u>Emiliania huxleyi</u> ubiquitous. The abundance of the cold water form of <u>E. huxleyi</u> in the Galapagos waters represented a phytoplankton indicator from the Peru Current System that was still abundant 225 km west of the islands. Other common coccolithophorids included Cyclococcolithus leptoporus and Gephyrocapsa oceanica. Generally, at stations distant from land, or to the southeast of the Galapagos, the diatoms were in lower concentrations and the phytoflagellates predominated. Diatoms were most numerous at off shore stations and in the protected bays of the island complex. The most common pyrrhophyceans included Geratium declinatum, C. paradoxides, C. trichoceros, and Danasphaera indica. The silicoflagellate, Dictyocha fibula was also common in the island waters.

ABSTRACT. SOME ASPECTS OF BARK ULTRASTRUCTURE. Robert E. Martin. Division of Forestry and Wildlife Sciences, V.P.I.& S.U., Blacksburg, Va. 24061.

Both phloem and rhytidome have important functions in the life of trees. Due to its active physiological role, phloem has received much more attention than rhytidome. We, however, have been concerned primarily with the structure and properties of the rhytidome, and particularly with the phellem cell of the pines.

A diagram of pine bark is presented, and various aspects of bark structure are illustrated, mostly with scanning electron micrographs. General rhytidome structure is outlined, and the types of cells occurring in bark are discussed. Rhytidome contains old cells from the phloem as weil as the cells of the periderms. Live cells are usually crushed, but parenchyma cells often expand in diameter. Sclereids and fibers remain intact, and ray dilation may occur. Periderms form as protective barriers at the outer edge of the old phloem, as parenchyma cells become meristematic.

The structure and properties of cells in the periderms are not clearly understood, but we have attempted to develop techniques for obtaining better data on them.

EARLIER YEARS OF THE FLORA COMMITTEE. A. B. Massey. Div. of Forestry & Wildlife Sciences, V.P.I. & S. U., Blacksburg, Va., 24061

The committee was organized by I. F. Lewis and Massey in 1926 and accepted by the Academy as an official standing committee. It continues as such today. Herbaria were developed at Lynchburg College, V.M.I., U. Va., and V.P.I. The latter is now the largest.

The committee published Merriman's Flora of Richmond and Vicinity and the periodical Claytonia which was discontinued in favor of the Virginia Journal of Science. Seven of my bulletins have been published by V.P.I. Several out of state botanists cooperated with the committee and issued publications.

A. M. Harvill, Jr. of Longwood College, is presently chairman of the committee of eight members.

BETULA UBER -- WHAT IS IT AND WHERE IS IT? Peter M. Mazzeo. U. S. Nat. Arboretum, Agri. Res. Service, U.S.D.A. Washington, D.C. 20002.

Until this past year little was known about Betula uber, a plant that was first described in 1918 by W.W. Ashe as a variety of the black birch, Betula lenta. This was based on specimens collected by Ashe in the mountains of Smyth County, Virginia. In 1945 M.L. Fernald, when making a study of the birches of North America, elevated it to specific rank, and placed it in the series Humiles where it properly belongs.

Since the original collections were made in 1914, no other living specimens have been located. The only material available appears to be the few herbarium voucher specimens prepared by Ashe in 1914, and deposited in various herbaria.

As a result, attempts are now underway to relocate the original collection site from field data on the original herbarium labels to determine if this tree is still extant.

From recent studies of herbarium material it appears as though Betula uber is a "good" species that belongs to series Humiles, and is most closely related to Betula pumila of the far northeastern United States and adjacent Canada.

Hopefully, further field work will uncover living specimens and more information about this rarest of North American birches.

THE COMPLEX ROLE OF FUNGI ON EARTH. Orson K. Miller, Jr. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061

In the last few years our knowledge of the interrelation-ships among fungi, algae, and higher green plants in arctic, subarctic, and boreal forest habitats has measurably increased. Primitive Basidiolichens are often found in the same habitats with plants and fungi which are symbionts in complex mycorrhizal relationships. Severe climatic extremes in mountainous areas have led to unusual adaptions to environmental conditions by fungi which allows them to adequately fruit and disseminate spores. It appears that distinct populations of some species of northern Basidiomycetes have influenced early man by the differential production of secondary metabolites or as a stable food base in specific regions.

EFFECTS OF SODIUM ACETATE ON THE GROWTH AND PHOTOSYNTHESIS
OF THE RED ALGA, PORPHYRIDIUM. P. T. Nielsen and D.A. Waite*
Biology Department, Madison College, Harrisonburg, Va., 22801

Biology Department, Madison College, Harrisonburg, Va., 22801
Cells of Porphyridium cruentum failed to grow in the dark
on agar slants of artificial sea water fortified with acetate
or glucose (10mM), suggesting that Porphyridium is an obligate photoautotroph. Growth on agar in the light was unaffected by the presence of glucose but was strongly inhibited by acetate. Manometric studies revealed that neither
glucose nor acetate can serve as a respiratory substrate.
The growth of liquid cultures responded in like manner to the
presence of glucose or acetate; acetate completely inhibited
growth in the light.

The effects of acetate on growth in the light can be attributed to its effect on photosynthesis. Sodium acetate (10mM) markedly inhibited photosynthetic oxygen production as measured manometrically. The time-course of the acetate-effect was strongly dependent on the pH of the medium. At pH's of 5.0 to 5.5, photosynthesis was completely inhibited within 5 minutes. At higher pH's the effect of acetate on photosynthesis became apparent more slowly, and above approximately pH 7.0 no inhibition was observed. The effect of pH is probably due to the predominance of the less permeable acetate ions at higher pH's. Possible explanations for the observed effect of acetate on photosynthesis are discussed.

SOME HISTOPATHOLOGICAL OBSERVATIONS ON FUSARIUM WILT OF "MIMOSA." P. M. Phipps* and R. J. Stipes. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The proliferation of the fungal pathogen (Fusarium oxysporum f. sp. perniciosum) in host (Albizzia julibrissin) tissues was studied during disease development. Sections of xylem vessels in asymptomatic branches of diseased trees often revealed the presence of conidia, while extensive mycelial growth and gum deposits were present in vessels of wilting branches. Hyphae were observed within pith, ray and vasicentric parenchyma, and among periderm cells. Our observations indicated that the pathogen entered branches by movement of spores in vessels, and proliferated laterally by invading rays. By these lateral avenues of transit, the pathogen reached more vessels of the stem and also the periderm tissues where lenticular sporodochia formed and produced abundant macroconidia. We suggest that a direct relationship exists between pathogenesis and the proliferation of the pathogen in host tissues.

SEASONAL STUDY OF THE PHYTOPLANKTON AT LAKE DRUMMOND, IN THE DISMAL SWAMP, VA. William H. Poore, Jr.* and H. G. Marshall, Dept. of Biology, Old Dominion Univ., Norfolk, Va. 2308

Lake Drummond is a shallow, acidic lake, located in the center of the Dismal Swamp in southeastern Virginia. Phytoplankton, hydrography, and chemical data were obtained over a 10 month period (June 1970 to March 1971) from two stations at Lake Drummond. Surface phytoplankton analysis, pH, dissolved oxygen, chlorophyll concentrations, and transparancy were recorded at two week intervals. Although numerous pulses occurred over this period, two major growth periods appeared in the spring and late fall. Minimal phytoplankton populations were present in late winter and summer months. There was little species diversity of the phytoplankton which was composed mainly of diatoms, desmids and phytoflagellates. The dominant species over the entire period were Asterionella formosa and Melosira Herzogii. Closterium gracile and Staurastrum paradoxum were common in the summer flora. The only cyanophyte noted was <u>Spirulina Nordstedtii</u>. The acidity of the open water for this period ranged from a pH of 3.2 to 4.4. Maximum phytoplankton counts were recorded in spring when 18.4 million cells per liter were noted. Supported in part by funds from the Virginia Academy of Science.

THE INFLUENCE OF WATER STRESS ON PARAMETERS OF GROWTH OF LIRIODENDRON TULIFFERA SEEDLINGS. P. E. Pope and H. A. I. Madgwick. Dept. of Forestry & Wildlife Sci., V.P.I. & S.U. Blacksburg, Va. 24060

The productivity of yellow poplar seedlings subjected to five levels of available moisture in two separate experiments demonstrated that total dry matter production decreased with increasing levels of moisture stress. Unit leaf rate (ULR) and relative growth rate (RGR) decreased with increasing moisture stress while leaf area ratio (LAR) decreased in the soil study but was unaffected in the solution study. Leaf area (LA), both total and individual, was increased with increasing available moisture. Total LA and ULR appeared to be responsible for final plant size. The percent (%) of distribution of new growth to leaves decreased with increasing moisture stress while the $\mbox{\%}$ allocated to roots increased until stress became severe. Cyclic induced water stresses were not effective in reducing leaf number, however, continuous stress conditions did reduce the number of leaves with increasing stress but only for the most severe stress. Increasing moisture stress was shown to reduce leaf weight proportionately more than leaf area hence there was an increase in leaf area: weight ratio up to stresses where water was 40 percent available.

THE BIOLOGICAL EFFECTS OF EXTRACTS FROM SPECIES OF CRATAEGUS. W. Stepka. Dept. of Pharmacy, Med. Col. of Va., \overline{VCU} , Richmond, Va. 23219

Around the turn of the century preparations of \underline{C} . $\underline{oxyacantha}$ were used by homeopaths in treating various cardiovascular disorders. There was, however, little agreement as to which of the specific abnormalities were alleviated by their preparations. Eventually a single clinical trial showed that an extract of \underline{C} . $\underline{oxycantha}$ alleviated hypertension. We have confirmed the hypotensive effect of preparations from this species on laboratory animals and have shown additionally that several other species native to the Eastern U. S. also possess similar properties.

PROPHYLACTIC AND THERAPEUTIC RESPONSES OF FUSARIUM WILT OF "MIMOSA" TO BENOMYL AND THIABENDAZOLE. R. J. Stipes, P. M. Phipps* and Donna R. Oderwald*. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The "Mimosa" or silk-tree (Albizzia julibrissin) con-

tinues to succumb to Fusarium wilt caused by the fungus, <u>Fusarium oxysporum</u> f. sp. <u>perniciosum</u>. Resistance in cultivars 'Charlotte' and 'Tryon' is reported variable or nil. We report herein our findings on an alternate route to disease control with benomyl (B) and thiabendazole (T), two new systemic fungicidal benzimidazole derivatives.
"Mimosa" seedlings grown in sand in the greenhouse were treated once before fungus inoculation or once, weekly or daily thereafter with various levels (10, 100, 500 ppm) of B and T. Disease preventive or curative responses were metered as percent disease development, growth (fresh weight) of intact plants and recovery of the pathogen in culture. At 100 and 500 ppm B caused foliar chlorotic mottling, while T produced marginal chlorosis and suppressed growth. At all dosage levels and frequencies, B reduced symptom expression and fungus recovery rate from diseased difference in prophylactic and therapeutic responses. These findings represent the initial stages of a research program designed to control a devastating vascular disease of a beautiful landscape ornamental in Virginia.

SOLIDAGO ROANENSIS PORTER - ORIGIN, RELATIONS, AND CONFUSED SPECIES. PRELIMINARY OBSERVATIONS. L. J. Uttal, Dept. of Biology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Solidago roanensis is usually found in the presence of S. arguta Ait. and S. curtissii T. & G. Superficially, it appears to be intermediate between the two latter species. The appearance of intergradation is abetted by frequent aberrant plants. S. roanensis has been suspected to be a hybrid derivative of the other species. A mathematical analysis of selected characters reveals that S. roanensis is a strong independent species. Its appearance of intermediancy is coincidental, though it occasionally crosses as do many goldenrods. S. roanensis is frequently confused with other thyrsoid goldenrods. Its most definitive character is elongate tri-nerved inflorescense bracts. To appreciate this character, the bracts should be dried. They are not always apparent in the field. In the course of this study, characterization of S. arguta and S. curtissii has been refined, in addition to that of S. roanensis. New range records for S. spathulata DC. have been discovered, based on plants which had been identified incorrectly as S. roanensis.

ECO-TAXONOMIC ANALYSES OF MAJOR FOREST TYPES IN FREDERICK CCUNTY, VINGINIA. William W. Wynn*. James Wood High School, Winchester, Va. 22601

This study was designed to find out what major forest

This study was designed to find out what major forest types are present in Frederick County and to discover the factors that are responsible for the distribution of the forests.

The county can be divided into two physiographic regions: the first, a ridge and valley region underlaid by sandstone and shale; the second, a valley region underlaid by limestone and shale. The first region is referred to as the Ridge area, and the second is called the Valley area. The Valley area can be divided into a limestone belt and a shale belt.

Six stands of trees were selected for study. Two were in the Ridge area, two were in the limestone belt of the Valley area, and two were in the shale belt of the Valley area. The vegetation of each stand was analyzed, soil properties were studied, and physical factors were measured.

The results of this study indicated that there are two major forest types present in the county which are evidently produced by topographical conditions. The Ridge area has an oak type forest dominated by chestnut oak, and the Valley area has an oak-hickery forest. There are no major differences between the forest stands of the limestone and shale belts of the Valley area.

Section of Chemistry

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12-14, 1971, Blacksburg, Virginia

BICYCLIC INTERMEDIATES IN THE SYNTHESIS OF PROPELLANE. James H. Allender*, Daniel W. Armstrong*, Robert J.Brumback*, David D. Collins*, Joseph B. Philips III*,

James K. Shillington, Dept. of Chemistry, Washington and Lee Univ. Lexington, Va. 24450

Three approaches to propellane [tricyclo $(4,4,4,0^{1.6})$ tetradecane] have been investigated. One synthetic route, involving a photo-activated Diels-Alder addition of butadiene to octalin has been abandoned because of sound contraindications from orbital symmetry theory. A second route involving standard Diels-Alder addition of butadiene to $\Delta^{9,10}$ -octal-1-one is more promising and in harmony with orbital symmetry considerations. Ring closure of the A9,10-octal-1-one is effected using a Freidel-Crafts reaction on γ -(1-cyclohexenyl)-butyryl chloride to produce the bicyclic compound. The third route investigated involves a $\Delta^{9,10}$ octalindione-1,5 intermediate obtained from octalin using Seo2 oxidation of the α -positions followed by Oppenauer oxidation to the diketone without disturbing the bridge unsaturation. A standard Diels-Alder addition of butadiene is likewise projected for this intermediate. (Aided by NSF grant GY 7221 and by Robert E. Lee Research Grants.)

ISOLATION AND VPC IDENTIFICATION OF STEROIDS FROM JELLYFISH. Charles E. Bell, Jr. and E. Jay Downs*. Dept. of Chemistry, Old Dominion University

Jellyfish, Chrysaora quinquicirrha were air dried, extracted with lipid solvents, and subjected to column chromatography using 325 mesh silica gel. The compositions of selected fractions were identified using thin-layer chromatography and vapor phase chromatography. (Aided by NSF Undergraduate Research Participation Grant (GY-7424)

THE PREPARATION OF SOME NEW o-TRIFLUOROMETHYLAZOBENZENES. P. A. Byrne, A. K. Clark, H. H. Clark, and H. C. White, Jr., of Chemistry, Old Dominion University, Norfolk, Department Virginia 23508.

o-Trifluoromethylnitrosobenzene was reacted with several ortho-substituted anilines in an attempt to evaluate the reactivity and synthetic utility of this reagent in the preparation of unsymmetrical ortho-substituted azobenzenes (I). Several previously unreported compounds have been prepared and characterized. Synthetic results and properties of the new compounds will be presented.

A STUDY OF INTERFACIAL RESISTANCES CAUSED BY DETERGENTS IN GAS ABSORPTION PROCESSES. <u>Jerry A. Caskey</u>, Yan Pui To*, Dept. of Chemical Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., and R. H. Herbert*, Enjay Chemical Co., Baton Rouge, La.

The effect of detergents in gas absorption processes has received increasing attention in the past several years. The present investigation was undertaken to determine the effect of the type and molecular weight of the hydrophilic functional group of the detergent molecules on the rate of gas absorption. A quiescent state absorption apparatus was used with carbon dioxide and water as the absorption system. Six surfactants were selected for study: n-octanol, 4octanol, lauryl diglycol amide, lauryl diethanol amide, sodium lauryl sulfate, and sodium dodecyl benzene sufonate. An interfacial resistance for several concentrations of each surfactant was measured. It was found that increasing the molecular weight of the hydrophilic group decreased the interfacial resistance of the surfactant also the octanol with the hydroxyl group at a branched position was found to cause a higher interfacial resistance than with the hydroxyl group at the end of the hydrophobic chain.

A NEW ION SOURCE FOR MASS SPECTROMETRIC SAMPLING OF SHOCK TUBE FLOWS. Carl Clark and George Sanzone. Dept. of Chemistry, VPI&SU.

Representative sampling of a jet orifice for mass spec-trometric studies has been shown to be dependent on the geometry of the ion source relative to the jet. Sampling must be carried out as close as possible to the orifice to minimize dynamic scattering effects and to decrease the rise time. The physical geometry must be built to limit the interaction of the ion source with the jet flow. Modified forms of the Pierce electron gun and novel ion optics configurations are employed to minimize the distance downstream of the nozzle where the flow is sampled.

The configuration involved allows this ion source to be placed closer to this jet orifice than other previously used right angle samplers, reducing the scattering effects and

transient rise time.

NOVEL ALDEHYDE SYNTHESIS <u>VIA</u> ORGANOBORANE CARBON MONOXIDE REACTIONS. R. A. Coleman, Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185, and Herbert C. Brown*, Dept. of Chemistry, Purdue Univ., Lafayette, Ind. 47907.

Trialkylboranes undergo a remarkably fast reaction with carbon monoxide in the presence of soluble metal hydrides: producing an intermediate which is readily oxidized to the corresponding aldehyde. For example, tricyclohexylborane is readily converted into cyclohexanecarboxaldehyde in 93%

The structure of the trialkylborane has little effect on the reaction rate or yield of aldehyde. Functionally substituted organoboranes are accommodated as well. Thus, methyl 10-undecenoate is converted into 11-carbomethoxyundecanal in 95% yield. The scope and mechanism of the reaction will be discussed.

PREPARATION OF α , α -DIFLUOROISOCYANATES. A. F. Clifford and

 λ. W. Thompson*. Dept. of Chemistry, Va. Polytechnic Inst.
 & State Univ., Blacksburg, Va. 24061.
 Carbonyl fluoride will add to alkyl, perfluoroalkyl, and aryl nitriles in anhydrous acids to form the appropriate α, α-difluoroisocyanate or perfluoroisocyanate. With acetonitrile the reaction proceeded slowly in anhydrous hydrogen fluoride or hydrogen chloride to yield a clear colorless liquid which was identified by infrared, mass, proton NMR, and fluoride-19 NMR spectroscopies to be α,α -difluoroethyl isocyanate. Increasing yields were achieved by having the ratio of acetonitrile to carbonyl fluoride greater or less than one, the optimum amount of anhydrous acid, the presence of an alkali metal fluoride and/or an increase in reaction time. The $\alpha,\alpha\text{-difluoroethyl}$ isocyanate reacted with anhydrous ethyl alcohol to form the carbamate which slowly decomposed by splitting out hydrogen fluoride. The addition reaction proceeded more rapidly, in comparison to acetonitrile, with propionitrile and less rapidly with trifluoroacetonitrile. Benzonitrile, in the absence of alkali metal fluorides, did not produce an isolable amount of α , α -difluorobenzyl isocyanate, but α,α,α -trifluorotoluene, 6-hydroxy-2,4-diphenyl-s-triazine. α,α -Difluorobenzyl isocyanate was produced in the presence of alkali metal fluorides along with a trace amount of α,α,α -trifluorotoluene. Cyanamide yielded trifluoromethyl isocyanate and cyanuric acid. Adiponitrile produced the $\alpha, \alpha, \alpha, \alpha', \alpha'$ -tetrafluorohexyl diisocyanate.

AN INVESTIGATION OF THE DESTABILIZING EFFECTS OF COMMON ANTI-ACID MEDICINES ON A SYNTHETIC COLLOIDAL SYSTEM. M.E. Counts* and W.A. Barkley, Dept. of Chemistry, Radford Col., Radford, Va., 24141

This investigation was concerned with the destabilization of a negatively charged Minusil-5 (air-floated silica) colloidal system by the anti-acids Maalox, Mylanta (main ingredients aluminum and magnesium hydroxide) and Tums (main ingredients calcium and magnesium carbonate).

Anti-acid portions of 0.001, 0.005. 0.010, 0.050 and 0.100 gm. were digested in equivalent volumes of 0.001N HCl to change the main ingredients to soluble salts. portions were mixed in liter volumes of 0.500 gm/liter Minusil-5 colloid solution.

Destabilizing effects were interpreted from turbidity and transmission changes for each system. Maalox was most effective in colloidal destabilization. With the concentration 0.100 gm/liter Maalox, percent increase in transmittance was 279.54% compared to 26.19% and 20.59% increases for this concentration of Mylanta and Tums, respectively. The corresponding percent turbidity reductions for these systems were 99.52%, 41.86%, and 8.89%.
The destabilization of the colloidal system is accounted

for by the effective surface charge reduction and consequent zeta potential reduction by the multivalent cations present in the anti-acids, particularly the aluminum cation.

PHOTOCHEMICAL IODINATION REACTIONS BY WAY OF THE CHARGE TRANSFER STATE. R. F. Cozzens and T. K. Brown, Dept. of Chemistry, George Mason College, Fairfax, Va. 22030

The role of the electronically excited state of the charge-transfer (CT) complex as an intermediate in the photochemical iodination of several benzene derivatives by I, was studied. Reactions were preformed by irradiation at those isolated wavelengths absorbed by the C-T complex. Reaction products were determined by TLC, IR, and in one case (ie. iodination of 1,3,5 trimethylbenzene) by formation of a derivative and subsequent analysis. Kinetic studies indicated a pseudo-first order reaction in neat solution of ${\rm I}_2$ in the benzene derivative which proceeded by way of the excited state of the CT-complex. Rate of reaction increased with an increase in the number of side group hydrogens on the benzene ring. Iodination of pure benzene was slow but occurred. The importance of the CT complex as an intermediate in many other reactions of interest was briefly mentioned.

The Oxidation of Vanadium (III) by Molecular Oxygen. B. A. DeGraff* and M. Z. Choi.* Department of Chemistry, Univ. of Va., Charlottesville, Va. 22901

The oxidation of V(III) in perchloric acid solution by molecular oxygen has been studied at pH 2.5. At lower pH, the rate law has the simple form, $\frac{d(VO^{+2})}{dt} = k_1(\frac{O_2)(V^{+3})}{(H^{+})}$. At pH 1.8

and at high V^{+_3} concentrations, an additional term is needed in the rate expression,

$$\frac{d(V0^{+2})}{dt} = k_1(\frac{0_2)(V^{+3})}{(H^+)} + \frac{k_2(0_2)(V^{+3})^2}{(H^+)^2}$$

Isotope experiments using $\mathrm{H}_2\mathrm{O}^*$ clearly indicate that none of the oxygen appearing in the $V0^{+2}$ product comes from the water. The kinetic and isotopic results can be accomodated by a mechanism involving a hydroxy bridged dimer of (V^{+3}) as the principal reactive species. Implications of the mechanism will be discussed.

MASS SPECTROMETRIC STUDY OF POLYDENTATE SCHIFF BASE COORDINATION COMPOUNDS. J. G. <u>pillard</u> and L. T. Taylor, Dept. of Chemistry, Va. Poly. Instand State Univ., Blacksburg, Va., 24061
The positive and negative ion mass spectra

The positive and negative ion mass spectra have been measured for the copper(II), nickel(II), and cobalt(II) molecular complexes of polydentate ligands derived from salicylaldehyde and various polyamines. Polymeric positive ionic species containing two metal atoms and one ligand were detected in low abundance. Ionization potentials have been measured and the magnitude of the potentials suggests that the electron removed upon ionization was associated with the metal. Negative ion spectra indicate the presence of molecular negative ions for all of the compounds investigated.

APPROXIMATE INTERACTION POTENTIALS FOR ELECTRON DONOR-ACCEPTOR COMPLEXES. M. C. Dyson and J. C. Schug, Dept. of Chem., V.P.I. & S.U., Blacksburg, Virginia 24061

We have calculated approximate interaction potentials for benzene-halogen and amine-iodine complexes. Coulombic interactions were calculated for molecules constructed from atomic monopoles and quadrupoles. Induction and dispersion terms were evaluated from long-range interaction theory. Charge-transfer and exchange interactions were based on semi-empirical formulas involving intermolecular overlap integrals.

Halogen-benzene interactions were evaluated for a variety of geometries. The axial configuration was consistently found to be the most stable, though it apparently is not very highly favored. The predicted equilibrium distance was found to vary regularly through the halogen series, but the energies did not yield a regular progression

For amine-iodine interactions, previous experimental studies of ultraviolet charge-transfer spectra have provided empirical values for the charge-transfer resonance term, as well as the total interaction energy. The calculated charge-transfer term was in good agreement with the empirical value. But considerable adjustment of the exchange-repulsion term was necessary in order to bring the total energy into agreement.

(Supported by a grant from the National Science Foundation.)

A BIOASSAY STUDY OF THE EFFECTS OF COPPER AND ZINC IN THE RAPPAHANNOCK RIVER ON THE SURVIVAL OF BLUEGILL SUNFISH (Lepomts macrochirus Raf.). Angela C. Eckhart* and Bernard L. Mahoney, Jr. Department of Chemistry, Mary Washington Col. Fredericksburg, Va. 22401

In connection with a broad evaluation of the water quality of the Rappahannock River ecosystem, a bicassay study has been made to determine the toxic level of Cu and Zn to bluegill fish. A static bicassay procedure using river water for test and control tanks was carried out over 96 hrs. at 20°C. Hatchery raised bluegills were exposed in separate experiments to Cu(0.10-4.1 ppm) as CuCl2 and Zn(0.60-9.8 ppm) as ZnCl2. Continual monitoring of Cu⁺² and Zn⁺² activities were made with an Orion divalent cation electrode(DCE) and total concentrations of Cu and Zn were determined by atomic absorption(AA). Water hardness, pH, temperature, and dissolved oxygen were also recorded during the test period.

absorption(AA). Water hardness, pH, temperature, and dissolved oxygen were also recorded during the test period.

The median tolerance limit(IIm) for Cu and Zn were as follows: Cu IIm 0.55, IIm 0.50, and IIm 0.50; Zn IIm 6.60, IIm 5.65, and IIm 3.20. A synergistic study involving both Cu and Zn(Cu 0.050-0.50 ppm, Zn 0.40-4.20 ppm) gave

a TLm of 0.27 ppm Cu and 2.00 ppm Zn for 24, 48, and 96 hrs.
The use of DCE, pH, and AA measurements for monitoring
activity and total concentration during bioassay experiments
provide information on the chemical forms of heavy metals
found in river environments. Such information is useful in
elucidating the mechanism responsible for the death of
aquatic life on exposure to heavy metals. (aided by NSF grant)

CALCULATION OF PRINCIPAL AXIS ORIENTATION OF ZERO-FIELD ELECTRON SPIN RESONANCE OF SOME POLYACENES IN THE TRIPLET STATE. L. Ivan Epstein, Dept. of Biophysics, Med. Col. of Va., Va. Commonwealth University, Richmond, Va. 23219.

The orientation of the principal axes of zero-field splitting of the lowest triplet energy level as it would manifest itself through electron spin resonance has been calculated for several homologous series of polyacenes. A simplified version of the method of M. Gouterman (J. Chem. Phys. 30, 1369 (1959)) was used, that is, Hückel molecular orbitals were used without taking configuration interaction into account. While this approximation yields only the order of magnitude of the electron energy of the molecule, it is believed to be sufficient when used to calculate any geometrical properties of the molecule. As any straight polyacene chain in the molecule is lengthened, one of the principal axes is found to align itself progressively with the long dimension of this chain, although the angle between this long dimension and the principal axis sometimes changes sign. However, when one end of the polyacene chain is progressively bent, the orientation of the principal axes varies erratically.

ONE-STEP PREPARATION OF , , DIALKYL DERIVATIVES OF PHENYL-ACETIC ESTER. Charles E. Gant and Homer A. Smith, Jr., *Dept. of Chemistry, Hampden-Sydney College, Hampden-Sydney, Va. 23943

Treatment of ethyl phenylacetate with 4 equiv of sodium amide in liquid ammonia followed by 4 equiv of ethyl bromide or n-butyl bromide gave the \sim , < -dialkyl ester in good yield. Under similar conditions isopropyl bromide gave only monoalkylation. Benzyl chloride gave no alkylation apparently because of preferential reaction with sodium amide to give stilbene. With methyl iodide dialkylation readily took place but much of the dimethyl ester reacted further with sodium amide to give the corresponding carboxamide. Formation of carboxamide was negligible when isopropyl or t - butyl esters were employed with methyl iodide. Substitution of potassium amide for sodium amide led to greatly decreased alkylation with ethyl or n-butyl bromide, ascribed to preferential reaction of alkyl halide with potassium amide. Use of only two equivalents of sodium amide led to mixtures of monoand dialkyl esters, ascribed to a moderate side reaction of alkyl halide with sodium amide.

SYNTHESIS AND PROPERTIES OF SOME ARYL-s-TRI-AZINES. J. S. Gillespie, Jr., S. P. Acharya*, and R. E. Davis*, Virginia Institute for Scientific Research, Richmond, Va. 23229

The synthesis and reactions of several substituted striazines have been studied in attempts to prepare 2, 4-bis (4-chlorophenyl)- \underline{s} -triazine-6-carboxylic acid, $\underline{2}$, and 6aldehyde, 7. The 2, 4-bis(4-chlorophenyl)-s-triazine derivatives proved to be surprisingly inert to a variety of reagents. 2,4-Bis(4-chlorophenyl)-6-methyl- \underline{s} -triazine, $\underline{1}$, could not be oxidized with any of a variety of oxidants. On bromination 1 gave 2, 4-bis(4-chlorophenyl)-6-dibromomethyl-s-triazine, 4, which was resistant to hydrolysis. $\underline{4}$ on oxidation with SeO₂ gave $\underline{2}$. $\underline{2}$ was also prepared by the oxidation of 2, 4-bis(4-chlorophenyl)-6-hydroxymethyl- \underline{s} -triazine, $\underline{6}$, with KMnO₄. $\underline{6}$ was also resistant to other oxidizing agents and could not be oxidized to 7. 2,4-Bis (4-chloroanilino)-6-methyl-s-triazine, 3, was also resistant to oxidizing agents. 2-Diazomethyl-4,6-dichloros-triazine, 10, on reaction with 4-chloroaniline gave 2,4bis(4-chloroanilino)-6-chloromethyl-s-triazine, 11. All efforts to prepare 7 were unsuccessful.

SPECTROELECTROCHEMICAL EVALUATION OF HOMOGENEOUS CHEMICAL REACTIONS. George C. Grant. Dept. of Chemistry, Va. Commonwealth Univ., Richmond, Va. 23220

Continuous monitoring of the optical absorbance of product solutions during an electrochemical experiment is a versatile technique for increasing understanding of electrode processes and for studies of reactive intermediates such as radical anions and cations. Results from computer aided numerical solutions to the boundary value problems indicate that rate constants as high as 10^3-10^4 sec⁻¹ can be measured for a first order chemical reaction following electron transfer—comparing favorably to stopped-flow techniques.

Selectivity in monitoring one particular species in the multicomponent product solution is controlled primarily by the wavelength dependence of the molar extinction coefficient and the largest measurable rate constant is limited by the smallest detectable absorbance change. Chemical systems with faster rate constants require millisecond reaction times and the heterogeneous electron transfer rate is progressively more important in this inherently consecutive reaction scheme. These influences have been quantitatively evaluated for potential step measurements.

THIO-ANALOGS OF NITROGEN OXYHALIDES. Richard S. Kampf and John H. Wise, Dept. of Chemistry, Washington and Lee Univ., Lexington, Va. 24450

An attempt has been made to produce the thio-analog of nitrosyl chloride, ClNO, using $\rm N_4S_4$ as the starting material. In a vacuum line, $\rm N_4S_4$ is sublimed through silver-coated glass wool to produce $\rm N_2S_2$. A mixture of the $\rm N_2S_2$ and Cl2 is subjected to an electrical discharge to promote radical combinations yeilding ClNS. Progress of the reaction is monitored by infrared spectra.

DIELECTRIC STUDIES OF INTRAMOLECULAR FORCES IN LIQUIDS.

David E. Kranbuehl. Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

A model calculation of the dielectric behavior of a

A model calculation of the dielectric behavior of a liquid whose molecules have conformation-dependent dipole moment components is presented. The molecules contain two groups of equal size which interact according to a parabolic and cosine potential of varying symmetry. Experimental measurements of the dielectric behavior of bipyridine, 2-2'-dibromobiphenyl and 4-bromobiphenyl in carbon tetrachloride are interpreted in light of the model calculations in order to examine steric hindrance and resonant effects. The intramolecular rotation barriers are characterized in terms of molecular friction constants, barrier height and barrier shape.

PHOTOPRODUCTION YIELDS OF SILVER-107M AND SILVER-109M.

J. J. Law, Dept. of Natural Sciences, Longwood College,
Farmville, Va. 23901

Metallic silver was irradiated with bremsstrahlung from a 3.5 MeV electron beam produced in a linear accelerator. The gamma activity of the metastable isomers, Ag-107m and Ag-109m, was measured with a Ge(Li) detector coupled to a 1024-channel analyzer. The photopeaks of these isomers, the identification of which was confirmed by their energies and half-lives, were resolved and distinct. No photodisintegration was observed.

The ratio of the net Ag-107m photopeak count to that of Ag-109m was found to be (4.2 \pm 0.3): I. The ratio of the activation cross section for Ag-107(γ, γ')Ag-107m to that for Ag-109(γ, γ')Ag-109m was calculated as 2.9: I. The apparent cross section for Ag-107,109(γ, γ')Ag-107m, 109m was estimated to be 1.6 \times 10-1 μ b. The cross sections for Ag-107(γ, γ')Ag-107m and for Ag-109(γ, γ') Ag-109m were calculated as 1.2 \times 10-1 μ b and 4 \times 10-2 μ b respectively.

The findings may be of some practical value for the determination of the composition of enriched silver isotopes.

THE COLOR BLIND TRAFFIC LIGHT - AN UNDERGRADUATE EX-PERIMENT USING AN OSCILLATING REACTION. John F. Lefelhacz, Department of Chemistry, Virginia Cammanwealth University, Richmand, Virginia 23220

A novel approach to the laboratory study af chemical kinetics by nan-science students has been devised. In this experiment students investigated the influence af temperature, concentration, and a catalyst on the rate af an oscillating reaction reported by G. T. Kasperek and T. C. Bruice, <u>Inorganic Chemistry</u>, 10, Na. 2, 382 (1971). Students are excited by this type af reaction nat only because of its visual appeal, but also because they can appreciate the relationship between ascillating reactions and bialogical clack reactions. In the reported reaction, malonic acid is oxidized by Ce⁺⁴ ian in the presence af BrO₃⁻ ion which reoxidizes the Ce⁺³ ian to Ce⁺⁴. The periodic decrease and increase af Ce⁺⁴ ian is followed by the color change induced in the redax indicator ferroin. The details and major advantages of this experiment will be presented.

STRUCTURAL STUDIES ON A PURIFIED COMPONENT FROM THE TRICHO-DERMA VIRIDE CELLULASE SYSTEM. Betty W. Li*, John A. Lang*, and Ross D. Brown, Jr., Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State U., Blacksburg, Va. 24061

Multiple hydrocellulase (C1) enzyme proteins, required for the microbial degradation of crystalline cellulose, have been obtained through anion exchange chromatography and preparative disc gel electrophoresis. The C1 enzymes, A, B, and C, are glycoproteins with molecular weights of 34,500, 51,000 and 55,000, respectively and are very acidic, having isoelectric points around 3.5.

Preliminary structural studies are in progress on the purified component C of the enzyme system. Determination of the nature of its sulfur content revealed the presence of eight disulfide linkages and the absence of any sulfhydryl group in the protein. End group studies indicate the possibility of a blocked N-terminal residue. Peptides prepared by cyanogen bromide cleavage of the protein have been separated for investigation of the amino acid sequence. (Supported by USDA CSRS Grant 916-15-27.)

THE HYDROGEN ION DEPENDENCE OF THE OXALATE CATALYZED REACTION OF CHROMIUM(VI) WITH ARSENIC(III). J. G. Mason and S. Lowry*, Dept. of Chemistry, va. Polytechnic Inst. and State Univ., Blacksburg, va. 24061

The reaction between chromium(VI) and arsenic (III) in acetic acid-acetate buffers has been found to be catalyzed effectively by oxalate ion. Stoichiometric studies under reaction conditions have established that no induced oxidation of oxalate ion occurs. Detailed kinetic studies as a function of the concentrations of As(III), C204, and hydrogen ion have established the rate law as

 $\frac{-d\sqrt{Cr(VI)}}{dt} = \frac{k\sqrt{As(III)}\sqrt{H}+\sqrt{C_2O_4}\sqrt{Cr(VI)}}{1 + k\sqrt{As(III)}\sqrt{III}}$

for the catalyzed reaction. The full form of the rate law could be observed only in the more alkaline buffer compositions. The oxalate catalyzed reaction exhibits no dependence on the acetic acid concentration of the buffer in contrast to the uncatalyzed reaction between chromium(VI) and arsenic(III).

ADSORPTION FROM BINARY NONELECTROLYTE SOLUTIONS ONTO SILICA. D. R. Matayo* and J. P. Wightman, Chem. Dept., Va. Poly. Inst. and State Univ., Blacksburg, Va., 24061.

The composite and net adsorption isotherms for the systems benzene-cyclohexane, ethyl alcohol-cyclohexane, and ethyl alcohol-benzene on two silicas are reported. The first silica, a flame hydrolyzed silica, Cab-O-Sil, and the second, a precipitated silica, Hi Sil 215 are compared for adsorption capacity in the three binary systems stated. The heats of wetting $\langle \Delta h_{\rm I} \rangle$ of both adsorbents in the three pure liquids were determined and it was found that $\Delta h_{\rm I}$ was ethyl alcohol > benzene > cyclohexane. The heat of wetting values were correlated with the amount of each adsorbate that was on the silica surfaces. The heat of wetting of Cab-O-Sil was also determined as a function of concentration in the ethyl alcohol-cyclohexane system. The heats were determined for bare Cab-O-Sil and Cab-O-Sil with a monolayer of ethyl alcohol on the surface from which the heat of monolayer formation of ethyl alcohol was obtained. Supported by NSF Grants GP-8448 and GP-212997.

CHROMIUM TRICARBONYL COMPLEXES OF 1, 3-DIARYL PROPYL-METHANESULFONATES. R. A. Mateer* and A. F. Johnson, Dept. of Chemistry, Univ. of Richmond, Richmond, VA., 23173.

Routes leading to the synthesis of several monosubstituted 1, 3-diphenyl-2-propyl methanesulfonates have been investigated. Studies on the \(\pi - \complexation \) of the methanesulfonates with chromium hexacarbonyl were initiated, and the reaction conditions established. Techniques for isolation of the tricarbonyl complexes and for identifying their structures were developed. The mono- and bis-\(\pi - \complexed 1, 3-\text{di-phenyl-2-propyl} \) methanesulfonates were prepared as well as the \(\pi - \complexes \) of several halogenated methanesulfonates.

TRIPLET STATE ENERGY TRANSFER IN RIGID MATRIX. G. W. Mushrush, Dept. of Chemistry, George Mason College, Fairfax, Va. 22030

Triplet-energy transfer from 2-acetylfluorene and 2-acetonaphthone to trivalent europium and terbium ions in rigid matrix was studied spectroscopically by minitoring the phosphorescence quantum yield and decay of the donor as well as the fluorescence quantum efficiency of the acceptor at different concentrations. It is suggested that transfer originates in the n,π^* triplet, which is only slightly above the lowest π,π^* triplet of the sensitizer. A proposed photokinetic scheme, consistent with the presumed exchange mechanism, which explains the observed behavior will be presented. The essential differences in the two systems with respect to the magnitude of the transfer rate constant will be discussed. (Aided by NTH grant 2166-1000)

TERBIC ION AS A SENSITIVE PROBE IN ORGANIC PHOTOCHEMISTRY.
G. W. Mushrush and <u>G. Haas</u>*. Dept. of Chemistry, George
Mason College, Fairfax, Va. 22030
Irradiation of bicyclo [2.2.1]-2-heptene in degassed 2-

Irradiation of bicyclo [2.2.1]-2-heptene in degassed 2-propanol with p-methoxyacetophenone as a sensitizer yields the trans-exo-trans dimer in 98% yield. In the presence of TbCl₃ the yield of dimer is considerably reduced. The lowest \underline{n},π^* triplet of the sensitizer is higher than the emitting resonance level of the Tb+3ion. The quantitative kinetic data derived are consistent with a mechanism in which energy transfer to the Tb+3 ion acceptor competes with the dimerization process for the \underline{n},π^* triplets of the sensitizer.

Measurements of sensitized fluorescence quantum efficiency at different ${\rm Tb}^{+3}$ ion concentrations permits the calculation of rate constants for the individual steps in the transfer process. The data were consistent with an intermolecular (collisional) transfer.

The rate of photo chemical conversion (dimerization) under continuous irradiation can be found from quantum yield measurements. (Aided by NIH grant 2166-1000)

POSITRON ANNIHILATION IN LIQUID CRYSTALLINE SYSTEMS.

J. <u>Blair Nicholas</u> and Hans J. Ache, Dept. of Chemistry,

Va. <u>Polytechnic Inst.</u> & State Univ., Blacksburg, Va. 2406]

Positron lifetime measurements were carried out in a

series of liquid crystalline compounds. The resulting lifetime spectra were decomposed into two components. The shortlived component (lifetime Υ_1 , and intensity $\mathbf{I}_1)$ was attributed to free positron and para-positronium annihilation whereas the longlived component Υ_2 , \mathbf{I}_2 was considered to be the result of ortho-positronium annihilation. Changes of Υ_2 and \mathbf{I}_2 during mesomorphic phase transitions are generally very small and can be related to the transition entropies involved, supporting the contention that the positron annihilation process is affected by variations in the structural regularities of the environment. Various mechanisms which could account for the observed changes of the positron lifetimes and their intensities at the phase-

transition points are discussed.

CONCFRNING THE REACTION OF 1,3,5-CYCLOOCTATRIEN-7-YNE AT VARIOUS TEMPERATURES. M. A. Ogliaruso, and A. S. Lankey. Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

1,3,5-Cyclooctatrien-7-yne (dehydrocyclooctatetraene) has been reported to be best prepared in ether at room temperature, to afford the highest yield of adduct with a trapping agent. We now report on how the yields of product from the reaction of this species with a trapping agent vary depending upon: a) when the trapping agent is added, and, b) the temperature employed. Our results indicate that contrary to previous indicated reports, dehydrocyclooctatetraene is best prepared and allowed to react at temperatures other than room temperature.

ISOTHIO CYANATE PREPARATIONS BY THERMAL DECOMPOSI-TION OF DITHIO CARBAMATE ESTERS. R. M. Ottenbrite, A. Nelson and S. Chow, Dept. of Chemistry, Virginia Commonwealth University

The pyrolysis of dithiocarbamate methyl esters of primary amines afford isothio cyanates in good yields. The scope and limitations of this reaction with regard to substituent effects on aniline

$$H S R-N-C-SCH_3 \longrightarrow R-N=C=S + CH_3 SH$$

systems will be presented. The mechanism of the decomposition will be discussed. It is thought to involve the tautomer intermediate iminomethylsemidithioketal.

$$H S$$
 $R-N-C-SCH \longrightarrow R-N-C-SCH_3$

The reaction of N-methyl dithiocarbamate methyl esters under

pyrolytic conditions will also be presented.

THE PREPARATION AND REACTIONS OF MONOETHYL-PHOSPHITOPENTAAMMINECOBALT(III) PERCHLORATE.

Richard A. Palmer, W. Leo Johnson, III*, and Clydette Powell*. Dept. of Chemistry, Old Dominion Univ., Norfolk, Va., 23508

The monoethylphosphitopentaamminecobalt(III) complex ion has been prepared by the reaction.

omplex ion has been prepared by the reaction of aquopentaamminecobalt(III) perchlorate with diethyl hydrogen phosphite. The infrared spectrum shows that the complex contains a Co-O-P bond. The complex was reacted with chromous ion in an oxidation-reduction reaction which is shown to occur wis an inpressional. which is shown to occur via an inner sphere reaction. The chromium III complex product of reaction. The chromium III complex product of this reaction appears to contain the same monoethyl phosphite ligand as that found in the cobalt III complex. The cobalt III complex was found to be inert to oxidation by acid permanganate solution. (Aided by the Old Dominion Univ. Educational Fndn. and NSF grant GY 7424)

THE HIGH TEMPERATURE THERMAL AND MAGNETIC PROPERTIES OF SILVER(I) CHROMATE. <u>James O. Pressley</u>*and Paul E. Field, Dept. of Chemistry, Va. Polytechnic Inst. and State

University, Blacksburg, Va. 24061
The high temperature relative enthalpy of silver(I) chromate has been measured over the temperature range 370° to 900°K with an isoperibol drop calorimeter. Measurements of an NBS sample of alumina showed the accuracy to be $\pm 0.5\%$ over this range. A first order transition at $752\,^{\circ}$ K was found to have a heat of transition of 2.2 kcal/mole. A second order transition near 550°K is indicated by a change in the slope of the enthalpy curve. Measurements of the magnetic susceptibility on a Faraday balance between 300 and 700 K indicate a magnetic anomaly in this region.

The heat content data analyzed by the Shomate method yields an equation which fits the data within 1.2% up to the first order transition. The heat capacity function obtained from this equation does not agree with the low temperature values given in the literature. An enthalpy function obtained from the data above the second order transition temperature gives a derived heat capacity which extrapolates to the low temperature curve and a lambda discontinuity between 300° and 550°K, thus confirming the unusual magnetic behavior observed. The magnetic susceptibility at 300 K is dependent on the thermal history of the sample and increases tenfold through five heating cycles up to 550 K.

EFFECT OF OXALACETATE REACTIVITY ON THE DETERMINATION OF GLUTAMATE OXALACETATE TRANSAMINASE ACTIVITY. R. E. Reed* and J. L. Hess, Dept. of Biochemistry and Nutrition, Polytechnic Inst. and State U., Blacksburg, Va. 24061

The assay of glutamate oxalacetate transaminase (GOT) requires recognition of any side reactions of oxalacetate. Crude oat leaf homogenates assayed for GOT by the malate dehydrogenase (MDH) coupled system show an equivalent response upon substitution of lactate dehydrogenase (LDH) for MDH. LDH does not react with oxalacetate. The non-enzymatic rate of oxalacetate decarboxylation measured spectrophotometrically at 250 nm is too slow to account for these results. Thus, the cross-specificity for the coupling enzyme must result from an enzymatic decarboxylation.

Oxalacetate concentrations may be measured directly at 280 or 260 nm. However, the keto form of oxalacetate has been reported as the enzymatically active species whereas the enol form is the species absorbing at 260 nm. Other structural anomalies may also exist. Commercial preparations of oxalacetic acid were subjected to melting point determination, gas-liquid chromatography of the trimethylsilyl derivative, and high voltage electrophoresis. Ultraviolet absorbancy studies of oxalacetate in dioxane ($\epsilon_{260} = 8.5 \times 10^3$) and dioxane-H20 were carried out to relate keto-enol equilibrium to spectral changes.

The relative importance of decarboxylation and keto-enol equilibration of oxalacetate depends upon the state of enzyme purity and should be considered in analyzing GOT.

PENTADENTATE LIGANDS II. NICKEL (II) COMPLEXES OF THE LINEAR SCHIFF BASE LIGAND DERIVED FROM OF THE LINEAR SCHIFF BASE LIGAND DERIVED FROM
2-PYRIDINECARBOXALDEHYDE AND BIS(3,3'-AMINOPROPYL)AMINE. C. T. Spencer and L. T. Taylor, Dept. of
Chemistry, Va. Poly. Inst. and State Univ.,Blacksburg, Va., 24061
Nickel(II) complexes employing the linear
potentially pentadentate ligand (PYDPT) derived
from 2-pyridinecarboxaldehyde and bis(3,3'-aminopropyll) amine have been prepared. Complexes of

propyl) amine have been prepared. Complexes of general formula Ni(PyDPT) X/PF6 where X = Cl⁻, Br⁻, I⁻, NO₃⁻, and SCN⁻ and Y = Cl⁻, Br⁻, NO₃⁻ and SCN⁻ have been isolated. Where X = PF6⁻, a complex of composition Ni(PyDPT) (H₂O) (PF6)₂ is formed. All complexes have been characterized by infrared and visible spectral measurements, magnetic susceptibility and conductometric measurements. Both in solution and ductometric measurements. Both in solution and in the solid state the materials give rise to a pseudo-octahedral coordination environment about the nickel(II) ion. The position of the lowest energy d-d transition in the solid state can be correlated with the relative location of X and Y in the spectrochemical series. In methanol solu-tion, conductance measurements suggest the replacement of X or Y by a solvent molecule to complete the six-coordinate structure. In nitromethane the complexes behave as 1:1 electrolytes.

THE REACTION OF HIGHLY HALOGENATED ORGANIC MOLECULES WITH SODIUM BOROHYDRIDE. T.L. St. Clair* and H.M. Bell, Dept. of Chemistry, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The reduction of some polyhalogenated compounds with sodium borohydride in water and DMSO has been investigated. The study was designed to determine what types of halogenated compounds would react with the hydride ion by substitution on halogen.

$$RX + H^{-} \xrightarrow{DMSO} R^{-} + HX$$

The investigation so far reveals that compounds of a general formula R-CCl $_3$ will usually react to give an intermediate of anionic character, R-CCl $_2$, when R is electron withdrawing. This anionic specie can then react in different manners, depending on the structure of R. One example of interest is

$$CC1_3-CC1_3 + NaBH_4 \xrightarrow{DMSO} CC1_2=CC1_2$$

where a ${\rm Cl}^+$ has been removed by the loss of a ${\rm Cl}^-$ to generate the double bond.

THE SYNTHESIS AND ALKYLATION BY GRAMINE OF SOME SUBSTITUTED 3-PIPERIDONES. Richard J. Sundberg, Woodfin V. Ligon, Jr., and Long-Su Lin, Dept of Chemistry, Univ. of Va., Charlottesville, Va. 22003

An approach to the 2-(3-indolylmethyl)-piperidine ring system which constitutes a major portion of the skeleton of such alkaloids as ajmaline, sarpagine and dregamine, is described. The synthesis is consumated by alkylation of 5-pyrrolidino-1,2,3,6-tetrahydropyridine derivatives (enamines of 3-piperidones) by gramine. The stereochemistry of the alkylation reaction will be discussed. The required 3-piperidones are synthesized from known 4-piperidones by (1) a Wittig reaction to a Δ^4 , -piperidine-4-acetic acid ester, (2) base-catalyzed or photochemical isomerization to the endocyclic 1,2,5,6-tetrahydropyridine-4-acetic acid ester, (3) epoxidation, (4) base-catalyzed opening of the epoxide to a 3-hydroxy- Δ^4 , -piperidineacetic acid ester, (5) hydrogenation and (6) Jones oxidation.

PHOTOCHEMICAL DECOMPOSITION OF o-SUBSTITUTED ARYL AZIDES IN DIETHYLAMINE. Richard J. Sundberg, Stuart R. Suter* and Martin Brenner*, Dept. of Chemistry, Univ. of Va., Charlottesville, Va. 22903

Photolysis of ten o-substituted aryl azide in diethylamine (DEA) has been shown to lead mainly to oxygen-sensitive metastable intermediates, rather than directly to the 2-diethylamino-3H-azepines which are commonly obtained from such photolyses. The oxidation products of the intermediates have been identified as 3-alkyl-2-diethylaminopyridines, 5-acyl-3-aklyl-2-diethylaminopyridines and 6-alkyl-7-diethylamino-2H-azepin-2-ones. Spectral data indicate that the oxygen sensitive intermediates are 3-alkyl-2-diethylamino-1H-azepines and this structural assignment permits mechanistic interpretation of the oxidation process.

Phenyl azide and p-tolyl azide, which lack ortho substituents, give no evidence that analogous <u>IH</u>-azepines have appreciable lifetimes under the conditions of the photolysis, although they may exist as short-lived intermediates.

POTENTIAL FIVE-COORDINATE TITANIUM(IV) COMPLEXES. D. W. Thompson, R. W. Rosser, C. Hicks, P. B. Barrett, Dept. of Chem., Col. of William and Mary. Williamsburg, Va. 23185 Compounds of the type Cl₃TiL (L = anions of dibenzoyl-

Compounds of the type Cl_3TiL (L = anions of dibenzoylmethane, benzoylacetone, acetylacetone, 3-cyanoacetylacetone 2-acetylcyclohexanone, and dipivaloylmethane) have been prepared from the reaction of TiCl_4 with a \$\beta\$-diketone in methylene chloride. No evidence was obtained from the formation of simple Lewis acid-base adducts. Molecular weight and conductivity studies in nitrobenzene are consistent with the Cl_3TiL being non-ionic and monomeric (i.e., 5 coordinate). These results are in accord with our previously reported results for Cl TiL (L = acetylacetonate, 3-methylacetylacetonate) and tribromo(3-methylacetylacetonato)titanium(IV). The above complexes react with Lewis bases as pyridine to yield six-coordinate adducts. Infrared and low temperature nmr studies will be discussed in terms of possible isomeric structures.

ANIONIC $\beta\textsc{-DIKETONATE}$ COMPLEXES OF TIN(IV). D. W. Thompson, and K. S. Wong, Dept. of Chem., Col. of William and Mary, Williamsburg, Va. 23185

other $\beta\text{-}diketones$ as benzoylacetone and dipivaloylmethane have been unsuccessful.

FURTHER STUDIES ON THE TAUTOMERISM OF 1,4-DIARYLBUTANE-TRIONES AND RELATED COMPOUNDS. Bryan G. Wells* and R. G. Bass, Department of Chemistry, Virginia Commonwealth University, Richmond, Virginia 23220. Previously it has been shown that a solvent dependent

Previously it has been shown that a solvent dependent equilibrium exists between the chelated enol form of 1,h-diphenyl-1,2,h-butanetrione, which predominates in CRCl₃, and its ring-chain tautomer, 2,5-diphenyl-2-hydroxy-3-furanone, which predominates in DMCO. Both isomers may be observed in 80% DCCl₂-20%DMSO-d as solvent and this equilibrium has been studied using nar. The enol-furanone ratio was not effected by concentration changes, but varied in a linear fashion with variations in the ratio of DCCl₂ to DMSO-d₆. The enol-furanone ratio was also found to vary with para substituents on the benzene ring and in a Hanmett study correlated well with o+. Preliminary kinetic data indicate that the vinyl protons of both tautomers are exchanged with deuterium at approximately equal rates in a first-order or a pseudo first-order process.

The nmr spectrum of dibenzoyl (nethylamino) ethylene indicates that it exists as the keto-amine in solution. In 80% DCCl_3-20% DMSO-d $_{0}$ two forms are observed which appear to be the result of double bond isomerization. On deuteration the vinyl proton for each isomer disappears at about the same rate in a first-order or pseudo first-order process, and the N-CH $_{3}$ signal collapses from a doublet to

a sirglet.

SYNTHESIS OF THE BENZTHIENO-(2,3-g)PTERIDINE RING SYSTEM. R. L. Williams, Department of Chemistry, Old Dominion University, Norfolk, Virginia 23508 and Patricia J. Ward, Radford College, Radford, Virginia

The synthesis and characterization of several examples of a new, fused ring pteridine system will be described. The general reaction involves the condensation of thianapthenequinone (1) with various diamino and polyaminopyrimidines to give the basic benzthienopteridine ring system (2). Evidence for covalent hydration will be presented for the pteridine (2), R=R¹=H.

HETEROCYCLIC STUDIES: BROMINATION OF ALKYL SUBSTITUTED QUINOXALINES. R. L. Williams, Glenn Jacobs and Stephen A. Cohen, Department of Chemistry, Old Dominion University, Norfolk, Virginia

Very little has been reported in the literature regarding the bromination of $\pmb{\mathcal{T}}$ -deficient heterocycles particularly the alkyl substituted species. We have recently examined the bromination of 2-ethyl-3-methylquinoxaline (1). Bromination was carried out in various solvents such as bromination products will be described together with certain pertinent spectral data. (Aided by Grant No - U.S. Army MA MD 49-193-66-69215.)

Section of Engineering

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12-14, 1971, Blacksburg, Virginia

A NUMERICAL TECHNIQUE FOR OPTIMIZATION OF STRUCTURAL RELIABILITY. H. P. Artis, and C. T. Herakovich. Ering Mechanics Dept., VPI&SU, Blacksburg, Va. 24061 Engineer-

A numerical technique for optimization of safety factors in two dimensional, pin-connected, determinate structures is presented. A first derivative optimization search technique is used in conjunction with a Monte Carlo analysis scheme for the evaluation of the convolution integral to obtain structural optimization with regard to safety factor. The optimization range is defined by the minimum area to prevent buckling and the maximum area acceptable to the designer.

The members of the structure are grouped according to area. The user must specify the applied loads, their probability distribution, the material yield stress and the geometry of the structure. The algorithm then determines the loading in each member and optimizes the structure. Solution stability is then investigated and if the solution cannot be shown to be stable, it is rejected.

Results are presented for several truss configurations with up to 100 members. Each problem was solved for the minimum area of each group, and then for the minimum number of groups of different area.

The algorithm is available as a FORTRAN 1V program com-

patible with the IBM system/360.

THE EFFECT OF POLLUTION LOAD ON THE VARIABILITY OF THE OXY-GEN SAG CURVE IN A POLLUTED STREAM. J. D. Brammer* and P. H. King. Dept. of Civil Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061

Many studies have been conducted in an attempt to formulate equations which can predict the effect of pollution loading on a stream's waste assimilative capacity. Until the recent development of a stochastic model by Thayer and krutchkoff, all these studies were of a deterministic nature and enabled prediction of only one definite biochemical oxygen demand or dissolved oxygen concentration at some time or location in a particular stream. The stochastic model gave the probability distribution of BOD or DO concentration at

any particular location along a reach of the stream.

The stochastic model thus enabled the calculation of mean BOD or DO values and inaddition enabled the analyst to set confidence limits on these mean values. Bosley, Cubulka, and Krutchkoff demonstrated that variability was related to temperature and turbulance. The object of this study was to determine the effect of substrate concentration on the variability of BOD and DO values. By keeping temperature and turbulence constant and by varying the substrate concentration, it was shown that variability increased with increasing BOD concentration. It was further shown that the quantitative extent of variability, A, may be determined by using a Poisson approximation in which Δ is taken to be the variance of the oxygen deficit, S^2 , divided by the mean oxygen deficit, $\overline{\mu}$. (Aided by EPA training grant WP-166)

NORFOLK AS AN URBAN HEAT ISLAND. K.P. Chopra and W.M. Pritchard, Dept. of Physics, Old Dominion University, Norfolk, Va. 23508.

The differential heating over urban and rural areas simulates effects similar to those caused by natural islands due to differential heating over land and water masses. The urban heat island effect results in weak elevated inversions over cities and results from the physical differences between cities and suburbs in four major respects: (1) shapes of terrain or surfaces, (2) thermal properties of surfaces, (3) sources or sinks of heat and moisture, and (4) quality of air. The resulting thermal stratification inhibits vertical mixing across the inversion layer. The presence of large water masses, as in coastal areas, produce diurnally varying breezes with their accompanying ventilation effect which is made complex by the presence of tall buildings. These features determine whether the locally produced pollutants can be quickly removed from urban air. The urban heat island effect in large cities is too complex to permit identification of cause and effect. Tidewater area provides a unique natural laboratory for urban heat island studies' because here the industrial and urban activity areas are quite separable from residential and rural areas. Some micro- and macro-scale features of Norfolk as an urban heat island including diurnal variation and influence of sea breeze are described.

DISCREPANCIES IN STANDARD METHODS FOR AIR POLLUTION MEASUREMENT. Edwin Cox III, Partner, Edwin Cox Associates, Richmond, Virginia 23223

The Clean Air Act, as amended in 1970, requires that on a non-confidential basis operations which are sources of air pollution must register quantatitive data about their emission. The present primary standards which have been established, together with the anticipated 30 to 40 secondary standards yet to be published, require analytical tools for source sampling which are not available. The present techniques too often are simply attempts to take laboratory equipment and convert it to field usage by strengthening it. New techniques are required - laser technology, light interference and like techniques offer hope. Equipment must be reliable, have a long life expectancy, and be capable of operation by technicians.

ADSORPTION OF PHENOL FROM AQUEOUS SOLUTIONS ONTO SOLIDS OF VARYING SURFACE ENERGY. L. R. Dole* and J. P. Wightman, Chem. Dept., Va. Poly. Inst. and State Univ., Blacksburg, Va., 24061.

The uptake of phenol from aqueous solutions were measured by gas-liquid chromatography on a graphitized carbon, pyrogenic silica, Teflon, nylon and two polyethylene powders. The surface areas of the graphitized carbon and silica were measured by nitrogen Brunauer-Emmett-Teller(BET) plots. In the case of the polymer powders, the areas were obtained using krypton. When the quantity of adsorbed phenol was normalized to unit surface area, the order of decreasing $% \left(1\right) =\left(1\right) \left(1\right) \left($ uptake was: nylon, polyethylene(Alathon), polyethylene (Microthene), graphitized carbon, Teflon and pyrogenic silica. Kinetic studies were attempted on the carbon, nylon and polyethylene. The phenol/water system is partially miscible and shows the classic S-shaped isotherm on the graphitized carbon. However the polyethylenes show a striking minimum at a relative concentration of five to six-tenths saturation concentration. Both Teflon and the silica isotherms appear to go through a maximum. The nylon isotherm is linear over the range of relative concentrations measured (0.01-0.3). Clearly, there are several possible processes determining the uptake of phenol, giving rise to at least three classes of isotherms. (Supported by OWRR Project No. A-026-VA).

AUTOMATIC BRAKING SYSTEM FOR MINE TRACK CARS.

J. P. Kuhn*, D. R. Beavers*, R. E. Wade*, C. D. Riffe*, D. R. Warner*, and C. E. Mercer*. Dept. of Engineering, Southwest Va. Cmnty. Col., Richlands, Va. 24641

A major problem in the mining industry is the design of an automatic braking system for underground track cars. The system must be feasible when considering such factors as limited space, strength, and reliability of the device. To accomplish the desired results a mechanism using hydraulics and mechanical linkages will amplify a limited force producing a much greater locking force on the vehicle's wheels.

The combined effects of high loads in the cars and inclination of the mine tracks lead to the substantial amounts of potential energy acquired by the car.

The braking device is automatically activated when the car reaches a "runaway" condition and serves to prevent large increases in the kinetic energy of the car.

DEVELOPMENT OF THE ALL ALUMINUM AUTOMOBILE ENGINE BLOCK. Harold H. Macklin, Jr. * Reynolds Metals Company, Product Development Div., Richmond, Va. 23261.

In December, 1958, Reynolds Metals Co. accepted the automotive industry's challenge to develop an all-aluminum engine block that would eliminate the need for the expensive iron cylinder sleeves and perform under all test conditions equal to or better than the conventional cast iron engines.

After 12 years of research and development

After 12 years of research and development involving more than 7000 hours of dynamometer, wear and endurance testing, over 2000 cold start tests, and nearly a million miles of road test, the objective has been achieved. This development reached fruitation on September 10, 1970, when Chevrolet introduced the new Vega 2300 car powered by the first all-aluminum engine utilizing the Reynolds' developed 390 alloy technology.

This paper describes Reynolds Metals Company's research and development of a new alloy (390), modified pistons, piston rings, a new cylinder bore finishing process, and die casting and machining technology.

THE ECONOMICS OF CHEMICAL TREATMENT OF TEXTILE WASTES. D.L. Michelsen, T.B. Fansler, and J.R. Snead, Chemical Engineering Dept., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Two economic studies have been made on the treatment of textile wastes: (1) the removal of color by foam fraction-ation from a simulated concentrated dispersed dye waste, and (2) the removal of color and COD from an integrated, untreated actual textile effluent using precipitation with alum and polyelectrolytes.

Foam fractionation with a 50 ppm cationic surfactant can remove 80% of color and 45% of the COD from a dye bath waste containing 400 ppm of COD and a light transmittance of 10% (750mpl). The chemical cost would be 21e/1000 gal.

Chemical precipitation with alum (40 ppm), H₂SO₄ (440 ppm) and purifloc C-32 (17.5 ppm) achieved 85% removal of COD, 75% removal of color and 90% removal of turbidity from a mill waste containing 300 ppm of COD, and a light transmittance 46% (350mµ) and turbidity of 23 JTU. The chemical costs were 16.8¢/1000 gal; sulfuric acid costs represent 38% of this cost.

In both studies the cost of chemical treatment is somewhat higher than biological treatment, but chemical treatment may be more effective on disperse dye and refraction organic removal. THE SOCIAL AND ECONOMIC IMPACT OF THE CLEAN AIR ACT. John T. Middleton; Deputy Asst. Admin. for Air Programs, Environmental Protection Agency, 5600 Fishers Lane, Rockville, Md. 20852

The Clean Air Act amendments signed into law on Dec. 31, 1970, are a mandate to prevent and control air pollution to the fullest extent possible with technology that is or can be made available. They suggest that technology includes much more than just add-on emission control devices for smokestacks and tailpipes. The Act says, in effect, that the Nation no longer will trim its clean air goals to match the least common denominator of economic and technological capability, but rather that progress in devising and amplying air pollution control techniques will have to be expedited to meet the goal of clean air in this decade. The Act is intended to require serious consideration not only of alternatives to the internal combustion engine but also of alternative transportation systems. The Act is intended to require States not only to examine the engineering design of new industrial plants but also to inquire as to whether such facilities will be located where they will do the least possible damage to air quality. The Act assigns major standard-setting and enforcement responsibilities to Federal and State officials, but it gives citizens the right to challenge the performance of those officials. These provisions of the Clean Air Act and others can, and almost certainly will, result in significant progress toward clean air, and they will have a profound economic and social impact.

BIOLOGICAL TREATMENT OF MUNITION WASTES. M. W. Nay* and C. W. Randall*. Dept. of Civil Engineering, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A report on the progress made of an investigation of the treatability of TNT manufacturing wastes with activated sludge is given. TNT manufacturing began during WW I. Its manufacturing method has remained virtually unchanged since that time, until just recently when a new process was introduced in a full scale plant operation. Early treatability investigations accomplished on wastes resulting from the old batch manufacturing process, during WW II, were largely negative in their findings, reporting that biological treatment was unsuccessful because of waste toxicity and physiochemical treatment marginally successful and prohibitively expensive. The passage of a series of strong water pollution control laws, culminating with the development of water quality standards, and the creation of Federal agencies responsible for the supervision of the environment; has provided sufficient justification for the re-evaluation of this project. The characteristics of the waste resulting from the new manufacturing process, called the counter-current continuous flow process, differ from the wastes of the earlier batch manufacturing process, primarily by removing the most toxic waste by-products. Additional supporting work concerning controlled culture degradation of a series of phenolic compounds, and work involving the identification of micro-organisms within activated sludge has provided addtional encouragement for this project.

EDUCATIONAL NEEDS FOR THE MAINTENANCE OF ATMOSPHERIC QUALITY.

N.T. Stephens*. Dept. of Civil Engineering, Va. Polytechnic
Institute and State Univ., Blacksburg, Virginia 24061

The attainment and maintenance of acceptable levels of atmospheric quality in an increasingly complex technological environment will require reorientation of educational programs at all levels. Implications of these changing educational needs for the elementary school level through graduate school and adult continuing education programs are discussed. For example, at the college level, changes in emphasis and additional informational input within traditional college engineering courses are examined in relation to the requirements for emission prevention.

A DIGITAL SIMULATION AND INVESTIGATION OF COMPUTER JOB SCHEDULING, DISCIPLINES. * R. E. Taylor and R. C. Heterick, System Development Department, Virginia Polytechnic Institute and State U.

This paper discusses the application of the General Purpose Simulation System (GPSS/360) to the construction of a model for the investigation of computer scheduling algorithms for the central facility at the Virginia Tech Computing Center. The paper discusses the general design philosophy of the simulation model methodology of the investigation. Several potential scheduling disciplines were investigated to determine the most desirable scheduling algorithm to employ for the operation of the central facility. The ultimate selection of a discipline based upon several criteria. Among these criteria are average turn around time per job based upon priority class, average utilization of the central processors, average utilization of the peripheral devices, overall average turn around time of a standard job in the system. The study was based upon simulation of several twenty-four hour periods of operation of the system. The only variance was the scheduling discipline as the job stream remained constant.

Section of Geology

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

PETROLOGY OF THE HILLSDALE LIMESTONE, UPPER MISSISSIPPIAN, WEST VIRGINIA. D. W. Blancher, Jr.*, and Nicholas Lampiris.* Dept. of Geology, Va. Polytechnic Inst., Blacksburg, Va. 24061

The Hillsdale Limestone accumulated in a quiet marine environment that was occasionally turbulent. Quiet water deposits are dominantly bryozoan biomicrites that contain fenestellid bryzoans that have not been transported. Higher energy beds are marked by the occurrence of echinoderm debris (echinoderm biomicrite) and introclastic material (intramicrite) that were transported into this environment. These low and high energy beds occur in a repetitive sequence. Pyrite and abundant organic matter indicate that mild reducing conditions were present beneath the depositional interface. Directly overlying the Hillsdale are biosparite beds of the lower Demmar Formation that contain oolites with rounded and abraded fragments of echinoderms, brachiopods, and dolomitic micrite intraclasts. This biosparite was probably deposited under more persistent high energy conditions.

Authigenic dolomite, chert, and pyrite occur within the calcitic Hillsdale Limestone. Dolomite appears as subhedral to euhedral crystals that are disseminated throughout the matrix, and it frequently occurs in stylolites. Chert is secondary, since it cuts across bedding and fossils. Clay minerals identified by X-ray techniques are predominantly illite and chlorite with minor amounts of montmorillonite.

SYMMETRY AND CRYSTALS. <u>F. D. Bloss*</u>. Department of Geological Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The nature of symmetry in crystals will be illustrated by slides that enable the student to comprehend the subject quickly and retentively. The pedagogic advantage of these illustrations relative to those from standard textbooks stems chiefly from their use of everyday objects to illustrate symmetry operations. As a result the student is better able to recall a visual picture of the illustration and thus of the symmetry concept it summarizes.

PERTURBATION OF A LOCAL MICROSEISMIC REGIME BY UNDERGROUND COAL-MINING. G. A. Bollinger. Dept. of Geology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Microearthquake activity was monitored for a three month period in the coal-mining region of Buchanan County, Virginia. The first two recording weeks were prior to the beginning of operation of an underground coal mine directly beneath the seismograph. A comparison of the "before" and "after" ambient levels of microearthquake occurrence indicated a sevenfold increase attendant with the development of the mine. Furthermore, a total of over 15,000 microearthquakes were recorded during the monitoring period, with the workday rate exceeding 30 events/hour. Rock bursts, roof falls, rock and coal fracturing ahead of the mine plow are believed to be the cause of the majority of these microshocks.

THE NEW SEISMOGRAPH STATION AT MADISON COLLEGE. G. A. Bollinger, Dept. of Geological Sciences, VPI & SU, Blacksburg, Va. 24061, and F. H. Campbell, Dept. of Geology, Madison Col., Harrisonburg, Va. 22801

The department of geology at Madison Col. recently acquired a short period, vertical component seismograph system. The installation includes (1) a single component, rectilinear writing, visual drum recorder; (2) a control console which houses recorder and calibration circuitry and a crystal controlled digital chronometer; and (3) a 1.0 Hz short period vertical component seismometer. A four band short wave radio receiver provides the National Bureau of Standards time code WWV for synchronization with the system chronometer.

The Madison Col. campus is underlain by limestones, dolomites and shales of Ordovician age. These rocks form a part of the southeast flank of the Harrisonburg syncline. The seismometer pit is anchored to bedrock shale of the Edinburg formation.

The installation is ideally located with respect to historical seismicity of the region. Because of the accuracy of the digital chronometer, we are well equipped to monitor earthquake activity on a global scale as well as the low level activity characteristic of Appalachian seismicity. The station will be registered with the Seismology Div. of

The station will be registered with the Seismology Div. of the National Oceanic Survey in Washington D.C. and thereby become part of the cooperative network that exists in this country. We expect the Madison Col. seismograph station to make worthwhile contributions to regional seismic studies.

CARBONATE PETROLOGY OF SILICIFIED KNOX GROUP DOLOMITES, CHRISTIANSBURG FENSTER, SOUTHWESTERN VIRGINIA.
Paul L. Broughton. Department of Geological Sciences,

Va. Poly. Inst. and St. Univ., Blacksburg, Virginia 24061
The carbonates of the Knox Group on the overturned
northwest limb of the Christiansburg anticlinorium, southwestern Virginia, belong to the parautochthonous Saltville block, and were deposited in shallow marine waters of the Appalachian miogeosyncline in Cambro-Ordovician time. Two periods of silicification interrupted the dolomitization process. Introduced silica promoted authigenic overgrowths on detrital quartz grains, enveloping previously formed dolomite rhombs. Silicification ceased and dolomitization was resumed. Then silicification was renewed with replacement of calcium carbonate by chert and microcrystalline silica. Dolomitization later went to completion. Overall, the silica content in the Knox increases from the base upward. In this area dolomitization practically ceased after the deposition of the Knox. The anticlinorium became a prominent reef in Middle Ordovician

THE CHESAPEAKE BAY - EARLY SCIENTIFIC ACTIVITY

ALONG ITS SHORES. R.L. Buchan, Library Director and J.L. Willis, Dept. of Biology, Eastern Shore Branch Univ. of Va., Wallops Island, Va. 23337 A brief sketch of the pre Civil War history of science of the Chesapeake Bay region is chronologically presented. The main approach is through brief sketches of specific contributors to science. Many men included were not principally scientists. Subjects covered include natural history, medicine, agriculture, mechanical arts, botany, oceanography and geology. Well known figures such as Thomas Jefferson as well as lesser known figures such as John Banister are treated.

VEIN ALTERATION IN TRIASSIC DIABASE IN NORTHERN VIRGINIA. H. M. Davies*, Dept. of Geology, Col. of William and Mary,

Williamsburg, Va. 23185
Prehnite filled veins are typical of the highly jointed diabase of the Triassic basin in northern Virginia. vein minerals include scapolite, apophylite, and zeolites. One particular sample from Virginia Trap Rock Quarry in Leesourg contains the vein minerals prehnite, calcite, and quartz. Nearest the vein, fibrous tremolite is the dominant alteration mineral. Outside this zone, chlorite and amphibole form pseudomorphs of pyroxene, particularly of exsolved pigeonite which has inverted to hypersthene. Primary augite remains unaltered. The intensity of the argillic alteration of plagioclase increases to a maximum near the vein. Plagioclase is a minor constituent in the fibrous tremolite zone and is absent nearest the contact of the quartz-prehnite vein.

The introduction of several secondary hydrous minerals suggests that the solutions which caused the alteration were hydrothermal. Carbon dioxide and water, leached from the surrounding sediments, could have provided the major constituents of the hydrothermal solutions. (Aided by NSF grant GY-7388)

HEAT PRODUCTION FROM URANIUM, THORIUM AND POTASSIUM IN ROCKS FROM VIRGINIA AND NORTH CAROLINA, Susie Epps* and John K. Costain*, Dept. of Geological Sciences, Va. Polytechnic Inst., Blacksburg, Va. 24061

A new laboratory has been developed to determine the amount of heat production in rocks due to uranium, thorium and potassium. Most of the heat leaving the earth can be attributed to the radioactive decay of the isotopes $\rm U^{238}$, $\rm U^{235}$, $\rm Th^{232}$ and $\rm K^{40}$ which are concentrated in the upper few tens of kilometers of the earth's crust. Attempts are being made to correlate observed variations in and potassium. Most of the heat leaving the earth can made to correlate observed variations in terrestrial heat flow and heat production in the southeastern part of the United States with regional geology.

Heat production in rocks is being determined using gammaray spectroscopy. Two Harshaw 3X3" scintillation detectors enclosed in a lead shield detect gamma-ray emission from rock samples. Spectra are compared with standard spectra of known amounts of uranium, thorium and potassium.

Preliminary results in Virginia and North Carolina give heat production values of 5.2 \times 10^{-13} cal/cm³-sec for the Striped Rock granite near Independence, Va., and 4.2 X 10⁻¹³ cal/cm³-sec for the Mt. Airy granite in Mt. Airy, N. C. In the northeastern part of the United States other workers have established an empirical linear relationship between theat flow, Q, and heat production, A, which is described by the equation Q = 0.85 + 0.0625 A. Using this linear relationship, measurements of heat production made thus far predict heat flow values which are in close agreement with those we have determined in the sou*hern Appalachians.

ATMOSPHERIC CARBON DIOXIDE -- A BUFFERED SYSTEM. Keith Frye, Dept. of Geophysical Sciences, Old Dominion Univ., Norfolk, Va. 23508.

Climatic change due to an accumulation of in-dustrially produced CO, has been postulated as en-vironmental threat. Réview of the geochemical cycle of carbon indicates that the system was in a steady state prior to the industrial revolution, and that atmospheric CO2 is transient. The CO2 increase in the atmosphere from an estimated preindustrial value of 290 ppm to the current 324 ppm accounts for only about one third of that produced by the combustion of fossil fuels. Extrapolations into the 21st Century are based on a continued exponential fuel combustion rate and on one-third retention in the atmosphere. This second assumption is unwarranted. Rates of removal of CO₂ from the atmosphere are functions of the amount of CO₂ there, and any increase in the partial pressure of atmospheric CO₂ leads to its faster removal from the atmosphere. Continued industrial combustion of fossil fuels may be expected to raise the CO₂ content of the atmosphere above current levels but the rate should be expected to decrease. THE STRUCTURE OF THE NORTHERN HALF OF THE RICHMOND BASIN. K. Goodwin, Dept. of Geology, Col. of William and Mary,

Williamsourg, Va. 23185 North of 37°30' north latitude, Triassic sedimentary rocks along the eastern edge of the Richmond Basin are nonconformable upon the Petersburg granite. This contact is offset locally along normal faults. Pronounced normal faults mark the western boundary of the basin where sedimentary rocks are in fault contact with granite, granite gneiss, and metavolcanic rocks.

Much of the major border fault is flanked by a 1000 foot wide zone of coarse boulder conglomerate in which angular boulders of metamorphic rocks attain diameters in excess of four feet and occur in a fine-grained matrix. Local offsets of this major fault occur along normal faults trending eastnortheast and west-northwest.

Although beds across the basin are dominantly westward dipping, a structure section along the James River shows an anomalous, apparently synclinal structure. This is considered to be due to the post depositional uplift of a large fault-bounded block of Petersburg granite which caused a major offset of the oasin's western boundary and deformation of the sedimentary beds. The pronounced fault exposed in the Boscobel quarry on the north bank of the James River is not flanked by boulder conglomerate and is considered to mark the eastern margin of the upthrown block of Petersburg granite rather than being the major western border fault.

A CONTROLLED COMPARISON OF THE EFFECTS OF ESCP AND TRADITIONAL EARTH SCIENCE ON STUDENT ACHIEVEMENT. Elrica S. Graham*. Pulaski High Sch., Pulaski, Va. 24301

Graham*. Pulaski High Sch., Pulaski, Va. 24301
This study was designed to determine if significant differences in achievement occur between students enrolled in the Earth Science Curriculum Project (ESCP) course and students enrolled in a traditional earth science course, when all the continuous predictor variables are controlled.

Subjects of the study were 116 ninth-grade students at Pulaski High Sch., divided into two groups, and all taught by the investigator during the school year 1969-70.

Null hypotheses were formulated that at the .05 level of significance there is no difference between students enrolled in the ESCP course and a traditional earth science course, after adjusting with covariates, in: (1) the ability to use scientific knowledge to solve problems, as measured by post-test scores on the STEP Science Test; (2) basic knowledge of the facts of physical and natural sciences, as measured by post-test scores on TOSK I; (3) basic knowledge of principles, methods, and procedures of science, as measured by post-test scores on TOSK II; (4) scores on TOSK Total; and (5) course grade point average. Least squares covariance analysis with multiple covariates was performed on the data.

Findings were that ESCP students showed significant gains, at the .025 level, in basic knowledge of principles, methods, and procedures of science, as measured by TOSK II. No significant differences occurred with respect to the other

criteria variables.

TURBIDITY MAXIMA IN TRIBUTARIES OF THE RAPPAHANNOCK RIVER, VIRGINIA, G. G. Gunia*, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Two tributary creeks of the Rappahannock River, studied

during the summer of 1970 and spring of 1971, were found to exhibit turbidity maxima similar to that found in the main estuary. Above the mouth of each stream, suspended sediment concentrations increased to a maximum, then decreased. The maxima were usually accompanied by Secchi discminima and salinities less than one part per thousand. Phase of the tide and surface runoff influenced the positions of the maxima. Higher current velocities increased the intensities of the maxima, indicating that resuspension of bottom sediments contributed to the maxima. The phenomenon is most obvious in early summer. During the spring, high sediment concentrations in the main estuary obscure the maxima in the creeks, and as the summer progresses, decreased runoff makes the maxima less distinct. A net ${\tt current}$ movement upstream along the bottom and downstream on the surface in Piscataway Creek may be the mechanism which produces the turbidity maximum.

COMPUTER DESCRIPTION OF TOPOGRAPHY. G. C. Grender. Dept. of Geological Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Topographic surfaces can be classified into seven basic forms: knobs, ridges, valleys, sinks, saddles, complex saddles, and slopes. Each of these can be further subdivided according to steepness and symmetry. Terrain can be considered as a set of points (each a part of one or more forms) rather than as a collection of landforms. The aggregate of points and their properties characterizes the topography. Scale is a fundamental factor in assigning points to forms; smaller areas about the point do not necessarily have the same shape as larger areas. The computer can be made to function as a "window" through which terrain can be viewed at various scales. The resulting arrays constitute an objective basis for terrain description.

SILICEOUS ERRATICS FROM THE LEADING EDGE OF THE CATAWBA-PULASKI FAULT, NORTHEAST OF BLACKSBURG, VIRGINIA. Stephen T. Hall*, and Michael E. Conefry*. Dept. of Geology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Several types of "erratic" cherts, siliceous oolites, and breccias were collected from the leading edge of the Catawba-Pulaski fault and grouped into four categories according to their composition, texture, or mode of formation. The stratigraphy of the Elbrook, Copper Ridge, Chepultepec, and Longview formations of the hanging wall was studied to determine if there was any significant correlation between siliceous rocks of these units and the "erratics". From studies of hand specimens, thin sections, and topography, the most probable origins of the "erratics" were determined to be: 1. cavernous chert - locally derived from the Elbrook, 2. fractured cherts - tectonically transported from the Copper Ridge by Pulaski thrusting, 3. breccia - Pulaski fault breccia containing chert and fine-grained sandstones of presently indistinguishable origin, and 4. siliceous oolites, uncertain derivation.

The Catawba-Pulaski fault is a reverse, bedding-plane fault having the same dip as the Mississippian strata of the footwall, about 35°. The dip of the fault and the proposed tectonic transport of many of the "erratics" due to thrusting support the theory that the Catawba-Pulaski fault is essentially the Pulaski thrust.

STRUCTURAL ANALYSIS OF THE BOWENS CREEK FAULT IN BASSETT QUADRANGLE, VIRGINIA. William S. Henika, Virginia Division of Mineral Resources, Charlottesville

The Bowens Creek fault, located along the Martic line in the southwestern Piedmont of Virginia, has been traced for fifteen miles from Philpott Reservoir across the Bassett quadrangle by detailed geologic mapping at 1:24,000 scale. The fault has a linear N. 50 E. trend and is the contact between high rank, polymetamorphosed rocks correlated with inner Piedmont Belt of the Carolinas and low rank metasedimentary rocks of the Lynchburg Formation.

Attitudes of foliation measured within a 2000 feet wide phyllonite zone that occurs along the fault have a steep dip towards the southeast. Axes of minor folds, boudins, crenulations, quartz rods and cleavage intersections indicate the 'B' tectonic axis is oriented nearly horizontal and is parallel to the fault trace. Mineral lineations, striations, stretched pebbles and streaks indicate the direction of tectonic transport was oriented at nearly right angles to the fault trace.

The orientation of the tectonic axes combined with the metamorphic and stratigraphic discontinuity along the fault trace indicate the polymetamorphic rocks were thrust from the southeast over the lower rank Lynchburg Formation.

MINERALOGIC VARIABILITY IN THE DIABASE OF NORTHERN VIRGINIA.

J. M. Keahey*, Dept. of Geology, Col. of William and Mary,
Williamsburg, Va. 23185

Mineralogic variation in the modal composition of diabases

Mineralogic variation in the modal composition of diabases in the northern area of the Virginia Triassic Basin has been revealed through the statistical treatment of modal analyses of fifty-one samples. Analysis of variance between and within nine quarries and the Tukey method of comparison of quarry means indicate that differences in modal compositions are significant rather than being deviations from a single mean. The percentages of pyroxene increases outward from the center of the area investigated and plagioclase feldspar varies inversely.

The Tukey method of comparison indicates that diabase within the same map unit may be similar with respect to the content of opaque minerals but may differ significantly in plagioclase and pyroxene content. The diabase in the three most southern quarries differs in biotite and micropegmatite content from the more northern quarries.

These factors suggest that the mineralogic variability in the diabase may be the result of the differentiation through time of a basic parental magma. (Aided by NSF Grant GY-7388)

CRANDALLITE FROM FREDERICK COUNTY, VIRGINIA. S. M. Knowlton* and R. S. Mitchell, Dept. of Environmental Sciences, Univ. of Va. Charlottes-

ville, Va. 22903.

Crandallite, CaAl₃H(OH)₆(PO₄)₂, as white chalky crusts and small white to brownish chalky spherulites (to 4 mm diameter), occurs on joint planes of Oriskany sandstone (Devonian) in a zone in the Virginia Glass Sand Corporation quarry, about 1 mile south-southwest of Gore, Frederick County, Virginia. The mineral was studied by X-ray diffraction analyses, spectrochemical analyses, and optical means. Spectrochemical data indicate the mineral is a strontian variety with from 1 to 3.5% Sr0. The mineral is optically positive with e = 1.61₈ and o = 1.61₆. Optical studies also show that fibers in the spherulites are elongated at right angles to [0001]. A small number of spherulites of white to yellowish-green vitreous wavellite occurs with the crandallite.

THE EFFECTS OF A BASIC INTRUSION ON THE ALKALI FELDSPARS IN THE PETERSBURG GHANITE MEAR DINWIDDIE, VIRGINIA. J. A. Kohler*, Dept. of Geology, Col. of William and Mary, williamsburg, Va. 23185

The Petersburg granite exposed in the Vulcan Materials Co. quarry near Dinwiddie, Virginia is fine grained and contains the essential minerals quartz, plagicclase, potassium feldspar and biotite. It is intruded by a diabase dike, about three feet thick that is parallel to a prominent joint set. The color of the granite has been affected by the intrusion. From the dike outward the granite is first greenish gray, then bright pink and then typical light tan.

Potassium feldspars were separated by heavy liquids from each of fourteen samples that ranged in distance from one inch to forty feet from the dike. X-ray diffraction data indicates that the potassium feldspar from each sample is identical; a microcline microperthite. The triclinicity is

nearly 100, indicating near maximum microcline.

The uniformity of thermal state suggests that either the dike was not hot enough to affect the feldspars; the cooling was slow enough to permit the feldspars to regain their former thermal state; or the dike is older than Triassic and subsequent regional metamorphism has erased the effects of intrusion.

CLAY MINERALOGY OF SOME ORDOVICIAN MISSOURI AND VIRGINIA K-BENTONITES. R.W. Lounsbury*, Dept. of Geology. Memphis State Univ., Memphis, Tenn.38111, and W.N. Melborn*, Dept.

of Geosciences, Purdue Univ., Lafayette, Ind. 47905.
Samples of altered volcanic ash, K-bentonite, were collected from Ordovician units in eastern Missouri and central and northern Virginia. Some A.P.1.Reference Clay localities in Virginia also were examined and the clays analyzed. K-bentonites from Missouri are 8-10 in. thick, occur as greenish-yellow, plastic layers in carbonate rocks, and weather white. X-Ray and DTA indicate the Missouri clay is composed of mixed-layer smectite(montmorillonite)-illite. Glycolation expands the smectite from 12.6 Å to 17 Å. Heating collapses the structure to

Sampled Virginia metabentonites or K-hentonites have less expansive clay and some do not appear to contain smectite. Gray, green, or pink K-bentonites as much as I ft. thick wary in thickness and induration in outcrops. This contrasts with 4 ft. thick, less indurated accumula-tions in Alabama and central Tennessee. These differences may relate to a greater intensity of deformation of the Virginia occurrences. K-bentonite near Stephenson, Va. averages 1 ft. thick, has more smectite than the metabentonites, but less smectite than Missouri localities. Samples from a nearby W. Virginia locality have clay mineralogy similar to the Stephenson occurrence. Clay sampled at Harrisonburg, Va. is illite with secondary gypsum.

THE OCCURRENCE OF OPALINE OUTGROWTHS ON THE LEE FORMATION OF WISE COUNTY, VIRGINIA. William P. Porter*. Dept. of Environmental Sciences, Univ. of Va. Charlottesville, Va. 22903.

Grayish multiform opaline outgrowths were observed on the middle and upper sandstone members of the Lee formation (Pennsylvanian) in Wise County, Virginia. The range of forms includes: glazes, botryoidal coatings, stalactites, stalagmites, and arborescent forms. The growths are porous in some cases, but very hard and compact in others. X-ray diffraction analysis initially produced amorphous structure patterns; after heating the material at 1000° C for 24 hours, however, good alphacristobalite patterns resulted, proving the opaline nature of the material. The largest forms are stalactitic and arborescent and

range up to 10 mm long. At one locality an entire cliff face is glazed with the material.

Petrographic analysis showed a concentric growth structure similar to that observed in calcite dripstone stalactites. Thin-section studies of fresh parent sandstone indicated the presence of small grains of amorphous material, possibly

the source of the opaline silica.

THE MEANING OF APPALACHIAN CONGLOMERATES. W. D. Lowry. Dept. of Geol. Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061.

Re-evaluation of Appalachian extraformational conglomerates

is long overdue and must be made if tectonic history is to be interpreted correctly. The Unicoi clasts in the basal Ridge-ley Sandstone at Fagg, Virginia were derived from the Blue Ridge anticlinorium in Devonian time when the Unicoi had already been downfolded 10,000 - 15,000 feet in the trough of the Catawba syncline. Unicoi clasts in the conglomerates interbedded with the Liberty Hall shale at Fincastle indicates about 3500 feet less structural relief in Middle Ordovician The Rockfish Conglomerate at the base of the Proterozoic Lynchburg may be nothing more than a Fincastle-type deposit unless it can be demonstrated that the clasts were derived from a previously metamorphosed Lovingston Formation. Quartz pebbles must be interpreted with extreme caution as they are subject to recycling. They are known to occur in the Ashe, Mt. Rogers, Unicoi, Bays-Mocassin, Tuscarora, Ridgeley, Cloyd, Lee and higher stratigraphic units. Quartz pebbles in the Unicoi may have been derived from quartz veins in the Little River - Lovingston Gneiss, from those in the Lynchburg - Carolina Gneiss, or from pebbles in the Ashe, or from older Precambrian terranes. Lower Paleozoic carbonate clasts in the Triassic Potomac basin indicate the Blue Ridge had already been breached there but their absence in basins farther south implies the James and Roanoke rivers were yet

BASEMENT CONFIGURATION IN GLOUCESTER AND MATHEWS COUNTIES. VIRGINIA, FROM GRAVITY AND MAGNETIC DATA. M. A. Sabet, G. Shaffer*, C. R. Smith*, and T. A. Woodruff*, Department of Geophysical Sciences, Old Dominion Univ., Norfolk, Va. 23508

A total magnetic intensity map was made for the area between the latitudes 37°14 and 37°37 N., and the longitudes 76°16 and 76°45 W. The map shows two major closed anomalies: a magnetic high occupying the western half of the map, and an adjacent magnetic low running almost parallel. Closures of the high and the low are 500- and 200- gammas, respectively. The crest is located about 2 miles northeast of the town of Gloucester, and the trough 4 miles west of Gwynn Island. Both anomalies change their trend from NE-SW in the southern half of the map to NW-SE in the northern half. This is interpreted to be caused by the presence of two distinct magnetic sources trending NE-SW and NW-SE. A Bouguer gravity map of the southern two thirds of the same area was made. It displays the same features observed in the magnetic map, and strongly confirms the presence of two distinct anomalous trends which intersect in the area. Both gravity and magnetic maps suggest the presence of NW-SE trending faults.

Quantitative interpretation of the Bouguer map was made along a N 80°E trending profile through the well drilled by Elkins Oil & Gas Company. The interpretation shows that the basement forms a nearly symmetrical, steep-sided ridge. The depth to the basement changes from about 3000 feet near Chesapeake Bay to about 700 feet south of the town of

Gloucester.

IMPLICATIONS OF DOLOMITE FRAGMENTS IN THE GOSSAN LEAD, CARROL COUNTY, VIRGINIA. Charles E. Sears, Dept. of Geology,
Va. Polytechnic Inst., Blacksburg, Va. 24061
 Watson in his Mineral Resources of Virginia mentions that

Watson in his Mineral Resources of Virginia mentions that the Gossan Lead veins have fragments of varying character cemented by sulphides, principally pyrrhotite, and that these rocks are not seen in the country rock nearby.

The Gossan Lead Fault is an en echelon system in the Fries thrust block which consists of gneisses and schist of the Lynchburg Formation of Precambrian age. In the vicinity of the Great Outburst in southwestern Carrol County, Shady-like dolomite fragments have been observed along with rather massive mineralized dolomite containing pyrrhotite and related sulphides. If the dolomite is Shady, it raises several interesting questions as to time of faulting and mineralization, and suggests that Paleozoic sediments must have a considerable eastern extension, at least 10 miles beneath the Blue Ridge Thrust, as the nearest Shady Dolomite occurs along the Blue Ridge Thrust Fault near Ivanhoe, Virginia to the northwest. The time of faulting and mineralization would have to be at least post-Shady and very likely Late Paleozoic.

X-ray diffraction, thin and polished sections, and X-ray fluorescence analysis show no distinguishable difference between the dolomite fragments in the Gossan Lead and the Shady Dolomite in the Austinville-Ivanhoe area along New River. TIDAL EFFECTS IN THE PHREATIC ZONE. S. C. Shine*, and W. J. Hanna.* Dept. of Geophysical Sciences, Old Dominion Univ. 23508

Measurements were made of water levels in shallow wells near the Virginia Beach solid waste disposal area and the head waters of Thalia Creek, a tidal stream. Surface water levels were obtained from Thalia Creek at a point nearest the waste disposal area and the wells. Data were taken at one hour intervals during a 12 hour period for each day of observation. Measurements were made on three days over a seven week period.

Water level data from wells and the creek were correlated and plotted by the least square method using the 4th degree polynomial to show tidal variations. Water level in the shallow wells can be related to tide level in the nearby stream. The amplitude variations in water levels due to the horizontal distance between the wells and the creek were calculated. Time lag in the tidal cycles was also calculated.

TEXTURAL VARIATIONS WITHIN THE PETERSBURG GRANITE IN RICHMOND, VIRGINIA. M. G. Simpson*, Dept. of Geology, Col. of William & Mary, Williamsburg, Va. 23185

Within the Richmond area, the Petersburg Granite is characterized by three textural facies: fine-grained non-porphyritic, medium-grained non-porphyritic, and porphyritic. Field observations show the fine-grained facies to be the only one in contact with the country rock, a hornblende-biotite gneiss. The contact between the finegrained and the medium grained facies is always sharp. The porphyritic facies grades into the medium-grained facies and cuts both the fine-grained and the medium-grained facies as dikes. These observations indicate that the order of intrusion was 1) the fine-grained facies, 2) the medium-grained facies, and 3) the porphyritic facies. Modal analysis and statistical tests show that the three facies have basically the same mineralogic compositions, but that there are a few statistical differences in the percentages of potassium feldspar, mafic minerals, and muscovite. In general, the compositions support the field observations that the fine-grained facies was the first to form from the melt which produced these three facies. Relatively higher percentages of muscovite, biotite, and myrmakite also suggest that the fine-grained facies crystallized from the most hydrous melt.

RADIOACTIVITY OF WHALE VERTEBRA FOSSILS FOUND IN CHESAPEAKE BAY AREA. J. J. Singh, E. Rind, and S. L. Seaton. NASA-Langley Research Center, Hampton, Va. 23365

Gamma activities of whale vertebra fossils found in the lower Chesapeake Bay area have been studied using a calibrated Ge(Li) counter and a multichannel pulse height analyzer. On the basis of the spectral analysis of the observed gamma spectra, it is concluded that mainly $\rm U^{238}$ and, to a lesser extent, $\rm Th^{232}$, contents of the fossils are the causes of their radioactivity. The measured levels of activity of some of the fossils are high enough to require caution against inhalation of fossil dust while cutting or polishing fossils in enclosed spaces. The ages of the fossils, as determined by the $\rm Pb^{206}/U^{238}$ and $\rm Pb^{208}/Th^{232}$ ratios, are of the order of 15 million years. The lead-uranium and lead-thorium isotopic ratios used in the age calculations are based on the assumption that all lead is radiogenic and that no gaseous intermediate radioactive nuclei have been lost from the fossils.

MOLLUSCAN PALEOECOLOGY OF LATE PLEISTOCENE SEDIMENTS FROM THE CONTINENTAL SHELF OFF FAISE CAFE, VIRGINIA. C. L. Stein*, M. G. Simpson*, and G. H. Johnson, Col. of William and Mary, Williamsburg, Virginia 23185.

A preliminary study was made of five cores taken from the continental shelf off False Cape, Virginia by the School of Oceanography, Old Dominion University. These cores, which range in length from three to ten meters, were taken at distances of 2.5 to 14.5 kilometers offshore and at depths between 10 and 20 meters. The cores contained a basal fine- to medium-grained sand, a middle greenish gray mud, and an upper fine- to medium-grained sand. Based upon radiometric dates, the upper sand is Holocene and the lower units are Wisconsinan in age.

Ninety-five species of gastropods and pelecypods were identified from the cores, but only a few of the species are restricted to specific lithologic units. The species diversity is lower in the muds than in adjacent sands. The pelecypod fauna is dominated by shallow-water, burrowing species. The variation in faunal composition indicates that the fauna changed in response to variations in substrate conditions, temperature, and salinity during the fall of sea level in mid-Wisconsin time and later during the rise of sea level in Holocene time.

A FRELIMINARY STUDY OF BRYOZOA OF THE LINCOINSHIRE LIMESTONE IN ROCKINGHAM CO., VA.. D. R. Suter*, Dept. of Geology, Madison Col., Harrisonburg, Va. 22801

A preliminary study of Bryozoans has been conducted in an

A preliminary study of Bryozoans has been conducted in an attempt to establish a relationship of rock units from various outcrops mapped as Lincolnshire in Rockingham Co., Va. by William Brent, 1960. By comparing specimens from six different collection areas, a definite relationship can be seen that suggests a correlation of the rock units. Only one location shows a nearly complete stratigraphic sequence. The Lincolnshire is Lower Middle Crdovician and lies between the New Market and the Edinburg limestones (Cooper & Cooper, 1946). It is gray to black, quite fossiliferous, with zones containing oblate black chert nodules which roughly parallel bedding planes. Calcified and silicified bryozoans are quite common in the Lincolnshire as well as fragments of brachiopods, gastropods, cephalopods, trilobites, and echinoderms. Study of the bryozoans was done by thin section and hydrochloric acid dissolving of the silicified specimens from the matrix. The following types of bryozoans have been collected in this study. Trepostomes include Monticuliporoids; Dekayia - Milne Edwards and Haime, 1851; Nichelsonella - Ulrich, 1889; Hallopora - Bassler, 1911; Hemiphragma - Ulrich, 1893; and Lamottopora - Ross, 1963. Cryptostomes include Ulrichostylus (a Heloporoid) Bassler, 1952; Rhomboporoids; Stictoporoids; and Pachydictyoids.

ACID DIFFERENTIATES IN THIASSIC DIABASE, BULL HUN QUARKY, LOUDG, COUNTY, VIRGINIA. C. E. Turner*, Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185

Of nine diabase quarries in the Morthern Virginia Triassic basin, only two expose abundant acidic differentiates. These occur in irregular masses and veins in both the Arlington Stone quarry and the Bull Run quarry. Samples of the differentiate from the Bull Run quarry differ from those of the Arlington Stone quarry described by Shannon; their lesser volume, finer grain size, and lower quartz content, as indicated by a lower abundance of micropegmatite, suggest that the diabase in the Bull Run quarry is not as well differentiated as it is in the arrington Stone Quarry.

The primary minerals of the unaltered differentiate are: pyroxene, plagiociase, rutilated quartz, skeletal magnetite, and sphene. The differentiate has oeen extensively altered by hydrothermal solutions that introduced clear secondary quartz, amphibole, chlorite, prehnite, calcite, and argillic material. (Aided by NSF Grant GY-7388)

CAVE OEVELOPMENT DURING A CATASTROPHIC FLOOD IN THE GREAT VALLEY OF VIRGINIA. Richard C. Vierbuchen, Jr.* and Conald O. Doehring, Washington and Lee Univ., Lexington, Va.and State Univ. of N.Y. at Binghamton, Binghamton, N.Y.

Cave Springs cave, located in the New Market and Lincolnshire formations about one mile northwest of Lexington, Virginia, contains a stream which enters and exits through localized fractures. Normally stream depth is less than 4 feet and the bedload is mud and gravel sized chert.

Ouring the night of August 19-20, 1969 a high yield, high intensity rainstorm associated with hurricane Camille produced catastrophic flooding of the region. Patina removal in the cave reveals that water depth exceeded 1D feet. Much of the freshly exposed rock is chipped, fluted and exhibits sharp, angular corners which elsewhere are missing. The bedload of the stream now contains increased amounts of limestone and to date discharge has remained above normal.

We hypothesize that recurring cataclysmic storms are an important factor in cave development. Abrasion, cavitation and evorsion played an important role at Cave Springs. Corrasion has promoted corrosion by exposing fresh rock, increasing surface area and allowing more water to enter the cave.

ENGINEERING GEOLOGY OF THE SECOND HAMPTON ROADS TUNNEL. W. H. Vogelsang and A. C. Munyan and J.S. Thornton, Jr., Froehling and Robertson, Inc. Richmond and Old Dominion University, Norfolk, Va. 23508

Construction of the second bridge-tunnel crossing of Hampton Roads, from Norfolk to Hampton, Virginia, involves some new techniques and instrumentation to establish, monitor and stabilize the westward extention of the south island now used for the first bridge-tunnel.

None-indurated strata below the bay bottom of the area of the south island poses substantial problems of both safety for the first tunnel and for adequate compaction of these strata in the area of the south island extention. STUDY OF THE HARRISONBURG, VA. WATERSHED AT RIVEN ROCK. <u>T. H. Weese</u>*. Dept. of Geology, Madison College, Harrisonburg, Virginia 22801

Obtaining potable water has become a major concern for many communities in the past decade and Harrisonburg, Va. is no exception. This study was conducted from September, 1970, to May, 1971. The Harrisonburg watershed at Riven Rock is located on the eastern slope of the Shenandoah Mountains. The amount of stream discharge was measured by use of a Gurley Pygmy Water Meter. The water was found to have an average of only 17 parts per miltion of inorganic residues and no organic indicator of pollution. By comparing the monthly precipitation of Riven Rock with two other weather recording stations outside the watershed, the mean monthly precipitation of the drainage basin could be extrapolated. The monthly precipitation from September, 1970, to May, 1971, was correlated to the discharge during the same period. It was found that only a fraction of the discharge for most months was used by the city. A good means to impound part of the excess runoff would be to construct dams in the Skidmore Fork and Dry River Fork which would store approximately 4 billion gallons of water. The dams would be anchored on Devonian Hampshire formation which from all available data seems to be adequate for the job.

Section of Materials Science

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

STRESSES OF HEXAGONAL DISLOCATION ARRAYS. N. M. Bassim and D. Kuhlmann-Wilsdorf. Dept. of Materials Science, Univ. of Va., Charlottesville, Va., 22901

The stresses in the vicinity of an hexagonal array of screw dislocations are investigated, using as a model a section thereof that fulfills Kirchhoff's law of Burgers vectors, which requires the addition of semi-infinite edge dislocations about the edges. The stress distributions are calculated with an electronic digital computer. The shear components of the stress tensor in cylindrical coordinates, i.e. $\tau_{\rm PO}$, $\tau_{\rm ry}$, $\tau_{\rm Oy}$, are graphically obtained from the computer line printer, using symbols of different darkness and overlaid characters to indicate stresses in various ranges of intensity. The results show a very complicated pattern around such a network. The computation is undertaken because of its importance in connection with stresses due to dislocation boundaries such as are frequently observed in annealed as well as workhardened metals. (Supported by AEC Contract No. AT-(40-1)-3108)

FRACTURE STUDIES IN STAINLESS STEEL WITH THE 500 kV ELECTRON MICROSCOPE. R. W. Bauer*, and H. G. F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Thin foil tensile specimens of solution treated polycrystalline 304 stainless steel were strained to fracture in the Univ. of Va. 500 kV High Voltage Electron Microscope by means of a hydraulically loaded tensile stage, in order to study the role of grain boundaries on crack propagation. The thickness of the electron transparent region of the tensile specimen, produced by a twin jet electropolishing technique, was approximately lµ. Video tape at 30 frames/second and individual micrographs were used to record the fracture process.

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Cracks propagated through individual grains in or near <110> direction by thinning both ahead of and adjacent to the crack. Cracks were observed to be stopped and blunted at grain boundaries until sufficient stress was built up in the adjacent grain for a non-crystallographic hole to form. The crack would then pass through the boundary, join with the hole, and propagate to the next boundary before repeating the same process. (Acknowledgment is made of support by the Office of Naval Research).

A STUDY OF THE INITIAL FORMATION OF LÜDERS' BANDS IN A DUCTILE MATERIAL. E. W. Brooks, Jr.*, H. F. Brinson* and C. T. Herakovich*, Dept. of Engineering Mechanics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060 The initiation of macroscopically non-uniform yielding

The initiation of macroscopically non-uniform yielding in the form of Lüders' Bands is discussed, with emphasis on the orientation of these bands across the front of flat specimens in uniaxial tension. The orientation is determined analytically in three separate ways: (1) using the "characteristics" of the partial differential equations governing plastic flow; (2) applying the Mises Yield Criteria; and (3) combining elementary strain transformations with the concept of elastic constraint.

Experimental data is presented in the form of photoplastic photographs of initial localized yielding in Lexan® Polycarbonate. Comparison of this data with similar data obtained by others using material of quite different atomic structure is presented. From this comparison general conclusions are drawn on the mechanism of localized yielding.

PHASE EQUILIBRIA AND Eu²⁺-ACTIVATED LUMINESCENCE IN THE Sr₃(PO₄)₂-Cd₃(PO₄)₂ SYSTEM. J. J. Brown, Jr., Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, and J. R. Looney, Chemical and Metallurgical Div., Sylvania Electric Products, Inc. Towanda. Penn. 18848

The phase equilibria relationships in the \$\rm Sr_3(PO_4)_2\$-\$\rm Cd_3(PO_4)_2\$ system were established in air using DTA and melting point data obtained from compositions previously equilibrated by solid state reactions. Evidence for the existence of a third previously unreported \$\rm Sr_3(PO_4)_2 polymorph, stable only above 1410°C, is presented. Cadmium orthophosphate is soluble in $\alpha\text{-Sr}_3(PO_4)_2$ to only one or two mole %. Approximately 12 mole % \$\rm Cd_3(PO_4)_2\$ is sufficient to completely stabilize \$\rm Sr_3(PO_4)_2\$ to room temperature. A minimum of 20 mole % \$\rm Cd_3(PO_4)_2\$ dissolved in \$\rm \gamma\text{-Sr}_3(PO_4)_2\$ lowers the inversion temperature to approximately 1075°C. A ternary compound, \$\rm Cd_2Sr_2(PO_4)_2\$, is characterized. The luminescence of \$\rm Eu^2+\text{-}activated \$\rm Sr_3(PO_4)_2\$ is very de-

The luminescence of Eu²⁺-activated $Sr_3(PO_4)_2$ is very dependent on the polymorph present at the reaction temperature. Only β -Sr₃(PO₄)₂ is an efficient host lattice, but the rapid reversible inversion to α -Sr₃(PO₄)₂ upon cooling is necessary for maximum luminescence. Substitutions of Cd^{2+} for Sr^{2+} in all three $Sr_3(PO_4)_2$ polymorphs rapidly quench the luminescence. Structural interrelationships involving all alkaline earth orthophosphates are discussed in view of the $Sr_3(PO_4)_2$ polymorphism.

DTA ANALYSIS OF POLYPROPYLENE-DILUENT SYSTEMS. E.K. Bullock* and A.L. Fricke, Dept. of Chemical Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

The effect of selected diluents on the melting properties of polypropylene were investigated by Differential Thermal Analysis using a Du Pont 900 DTA analyzer. Long chain normal alkanes were shown to be moderately good solvents for polypropylene, but energy density functions for polymer-diluent pairs derived from the data indicate that there is a maximum in the relation of solubility to alkane chain length. Results also indicate that substitution of a polar group on the \$\alpha\$-position of the higher alkanes gives only a moderate decrease in solubility, but substitution in the \$\alpha\$, w-positions gives almost complete insolubility. Dynamically, the melting point of the diluent-polymer system is relatively insensitive to the rate of heating, but the crystallization temperature is affected markedly by the cooling rate.

STRESS CORROSION CRACKING OF 304 STAINLESS STEEL AS OBSERVED BY SCANNING ELECTRON MICROSCOPY. G. S. Clevinger and J. L. Lytton, Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Scanning electron microscopy techniques have been employed in a study of the induction period prior to massive transgranular stress corrosion cracking of stainless steels. Standard U-bend configuration specimens having various surface preparations and heat treatment histories, and with a range of nitrogen contents, have been exposed for varying lengths of time in boiling magnesium chloride solution. The results indicate that microcracks may be present in these structures even for exposures well within the induction period. In those samples having electropolished surfaces, there are indications that cracking begins by a linear formation of pits, which subsequently develops into a preferential site for initiation of a fast growing crack. (Aided by AEC Contract No. At-(40-1)-4052)

A THERMODYNAMIC TREATMENT OF SURFACES ON SMALL PARTICLES. P. R. Couchman and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

For small particles, where the high area to volume ratio causes surface effects to be important, care must be taken in defining thermodynamic intensive parameters. The intensive variables conjugate to the extensive variable, area, are defined by analogy to similar definitions in typical bulk systems with three extensive parameters excluding area. Various points are raised concerning surfaces in general and in particular those surfaces on small particles. (Supported by AEC Contract No. AT-(40-1)-3108)

A NON-VISCOUS INTERPRETATION OF RATE DEPENDENCE IN THE QUASI-STATIC TENSILE TESTING OF METALS. <u>T. H. Dawson</u>, Dept. of Civil Engineering, Univ. of Va., Charlottesville, Va. 22901.

When a metal wire or rod is plastically strained in quasi-static tensile loading, the resulting stress is generally found to depend not only on the strain itself but also on the rate at which the strain is produced. To account for this rate dependence it is sometimes assumed that metal plasticity is governed by both strain hardening and strain-rate viscous mechanisms. An altogether different interpretation of this rate dependence follows, however, from the hypothesis that metal plasticity is controlled by a combination of the competing effects of strain hardening and time-dependent thermal softening.

The applicability of this latter hypothesis in explaining rate sensitivity is examined experimentally in the present work for the special case of room-temperature deformation of a common lead-tin alloy. Results show that the separate responses of this alloy to both constant stress and constant strain-rate loadings are accurately described by a single stress-strain-time deformation law and, consequently, that its rate dependence is, in fact, directly attributable to the thermal softening hypothesis.

This work was supported by the National Science Foundation.

GROWTH OF HIGHLY PURE SINGLE CRYSTALS OF COPPER.
H. M. DeJarnette* and W. J. Tropf*, Dept. of Materials
Science and Dept. of Physics, Univ. of Va., Charlottesville,
Va. 22903

Highly pure single crystals of copper are grown at random orientation from the melt in a vacuum furnace at ambient temperatures near the melting point. The crystals are then very slowly cooled to insure a low defect concentration. The properties of these crystals are investigated and compared to high purity copper crystals which have been conventionally grown from the melt, i.e. not at very high ambient temperatures and air cooled. X-ray, electron microscopy, chemical and mechanical tests are used. (Supported by AEC Contract No. AT-(40-1)-3108)

THE UNUSUAL ELECTRICAL EFFECTS IN ARSENIC-TELLURIUM SEMICONDUCTING GLASSES. <u>L. R. Durden</u>, L. H. Slack, Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, and P. R. Eusner, Mullite Corp. of America, Americus, Ga. 31709.

The electrical conductivity of Arsenic-Tellurium glasses increases exponentially with temperature, whereas, the conductivity of crystalline material of the same composition decreases with temperature. In the temperature range 30°C to 200°C, the conductivity of the glass increases three to four orders of magnitude and conductivity of the crystalline material decreases only slightly. Permanent conductance transitions in the amorphous materials are shown to be due to crystal formation. Threshold switching phenomena have been observed in both amorphous and crystalline samples and are shown to be related to Joule heating.

SURFACE APPEARANCE CHARACTERIZATION OF ALUMINUM SHEET. A. C. Eden*, Va. Polytechnic Inst. & State Univ., Blacksburg, $\overline{\text{Va.}}$ 24061, and H. Lee Craig, Jr., Met. Res. Div., Reynolds Metals Co., Richmond, Va. 23261.

In an effort to eliminate surface defects created in aluminum sheet by normal production, experiments were performed with chemical surface conditioning. Various chemical etches were tested separately to determine which treatments would eliminate surface defects.

Samples treated of 5657 alloy were submitted to the authors for scanning electron microscopic examination. Optical microscopy and reflectance testing were used in early study. The SEM photos, which were taken with the University of Virginia's Cambridge Stereoscan II, revealed good resolution at 10,000X. A close correlation between the interpretations of reflectance data and the SEM photos was discovered for the chemically treated mill finish surfaces.

A chromic-phosphoric etch merely removed the oxide film leaving the metal itself untouched. Three minutes of hot caustic etch left the surface rougher and slightly more level. The ten-second and one-minute caustic treatments did not significantly alter the appearance of the control. Both standard and the hot bright dips left a smooth, level surface. Mixed acid etch leveled and pitted the surface.

We conclude that to improve the surface appearance, the removal of both oxide and metal is required. The surface roughness or levelness is not important since caustic, bright dips, and mixed acid etch all improved the total reflectance.

The performance of aluminum alloys 5052, 6061, 3003 and alclad 3004 is reported after two years of operation in a distillation desalination pilot plant at Wrightsville Beach, N. C., for the Office of Saline Water. The plant operated over a temperature range from 65°F to 250°F and velocities from 5 to 6 fps. Three-quarter inch aluminum tubes were installed in steel vessels with aluminum tube sheets. Galvanic corrosion occurred when plastic insulating sleeves and washers failed. A redesign was made to eliminate the galvanic corrosion. Alloy 5052 performed best

PERFORMANCE OF ALUMINUM ALLOYS IN DISTILLATION DESALINATION. <u>D. A. Fauth</u>*. Product Development Division, Reynolds Metals Company, Richmond, Va.

num tubes were installed in steel vessels with aluminum tube sheets. Galvanic corrosion occurred when plastic insulating sleeves and washers failed. A redesign was made to eliminate the galvanic corrosion. Alloy 5052 performed best but did suffer some attack at the ends of a few tubes in the hottest section due to a network of grain boundary precipitate. Alloy 30C3 tubes sustained some pitting attack. Alloy 6061 showed severe pitting attack and has been eliminated as a candidate alloy. The cladding on the alclad 3004 tubes did protect the core but was expended too rapidly to give lasting protection above 150°F. The overall performance of aluminum materials was very encouraging.

PHASE EQUILIBRIA IN THE SYSTEM BaO-SrO-SiO₂. <u>J. M. Fields</u>, P. S. Dear, and J. J. Brown, Jr., Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The phase equilibria relationships in the system, BaO-SrO-

The phase equilibria relationships in the system, BaO-SrO-SiO2, were established in air using conventional solid state techniques. The SrO-SiO2 boundary system was completed by determining the liquidus temperatures for the SrO-rich portion of the diagram. The three compounds SrSiO3, SrySiO4, and Sr3SiO5 melt congruently at 15800+50C, 23250+150C, and 21700+150C, respectively. Simple binary eutectics exist between i) Sr2SiO4 and Sr3SiO5 at 21500+15°C and approximately 27 mole percent SiO2; and ii) Sr3SiO5 at SrO at 20800+15°C and approximately 23 mole percent SiO2. All Alkemade lines were established for the ternary system, two of which were examined in detail because of extensive solid solution regions. In the Ba2SiO4-Sr2SiO4 join, a maximum solubility of approximately 70 mole percent strontium orthosilicate in barium orthosilicate exists at 2110°C, the eutectic temperature. Only 5 mole percent Ba2SiO4 is soluble in Sr2SiO4 at this temperature. The BaSiO3-SrSiO3 join contains limited solid solution regions which arise from the solid solubility of 40 mole percent SrSiO3 in BaSiO3 and 20 mole percent BaSiO3 at the eutectic temperature of 1210°+15°C. Only one ternary compound was found, BaSrSi3O8, which appears to melt congruently at 1325°+15°C.

THERMAL CONDUCTIVITIES OF POLYMER MELTS. T.R. Fuller*, A.L. Fricke, and <u>J. Ramsey</u>*, Dept. of Chemical Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24061.

A concentric cylinder, thermal conductivity cell with axial guard heaters was constructed and used to determine thermal conductivities of some commercially important polymers. The cell was constructed so that melts could be loaded easily with a minimum of degradation by oxidation, and so that good thermal contact with the cylinder walls could be maintained. Thermal conductivities of the melts were determined as a function of temperature from the melting point to approximately 100°C above the melting point. Thermal conductivity was found either to increase linearly with increasing temperature or to be independent of temperature, and to decrease with increasing chain complexity or polarity for the polymers studied. For these polymers, the order of thermal conductivity is linear polyethylene > branched polyethylene > polypropylene > styrene > nylon 6 > nylon 6/10. The results are precise to within six per cent and accurate to within thirteen per cent. Results for polyethylene and polystyrene agree well with those of P. Lohe, but the results for nylon 6 differ considerably.

APPLICATION OF STATISTICAL TECHNIQUES TO CERAMIC PROCESS ANALYSIS. <u>Cullen L. Hackler</u>*, Department of Metals and Ceramic Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061

Two statistical techniques, analysis of variance and multiple regression, are powerful tools in process analysis. If one is careful to follow the experimental schemes of statistics, then the application of analysis of variance yields quantitative insights into the sources of variation in a process. Often the object of an experiment may best be evaluated by fitting the data with a curve. Multiple regression is a straightforward method of determining this equation, provided the data have been properly taken. The role of the Ceramic Engineer is that of linking statistics to ceramic technology.

ELECTRICAL MEASUREMENTS OF GLASS THIN FILMS. M. R. Hall, L. H. Slack, and J. J. Brown. Dept. of Metals and Ceramic Engineering, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Thin film capacitors were made by electron beam melting of silicate glasses in a vacuum chamber. The bulk glasses were luminescent, containing 3 to 6 mole per cent of europium oxide, as well as lithium or barium oxide. Films containing lithium had a similar dielectric dispersion but a large variation in dielectric constant and dissipation factor caused by deviation of the lithium content from the bulk composition. Films containing barium had a much smaller variation in dielectric properties, but appear to be deficient in barium as compared to the bulk. The temperature dependence of the dissipation factor for the lithium containing films obeys the relation log(tan $\delta) = \log K + \alpha T$ with K = 3.02 x 10 $^{-3}$ and $\alpha = 6.9$ x 10 $^{-3}$ (°C) $^{-1}$ from room temperature to 150°C. At higher temperatures the films deteriorate rapidly.

FRACTURE STUDIES OF BORON FILAMENT-ALUMINUM MATRIX COMPOSITE. H. W. Herring. NASA-Langley Research Center, Hampton, Va.

The tensile fracture of thin sheets of uniaxial boron filament reinforced aluminum was studied using microradiography and acoustic emission techniques. The resulting fracture surfaces were observed under the scanning electron

A peculiar fracture mechanism was identified which severely limited the ultimate strength of the composite. This mechanism was initiated by fracture of one of the weaker filaments in the composite, with the energy pulse released locally by the initial break being alternately damped and reinforced by the rapid sequential fracture of a multiplicity of adjacent filaments. Fracture of the aluminum matrix occurred in a ductile manner after the filaments had broken.

The observed fracture mechanism was related to current theory on tensile failure of composites in terms of the statistical distribution of ultimate filament strengths. It was found that composite tensile strength could be predicted within reasonable limits from filament strength data and a knowledge of composite fabrication parameters

A NEW DENTAL AMALGAM. Lewis B. Johnson, Jr., Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Amalgam specimens have been prepared from an alloy containing 10 weight percent Au, 64 percent Ag and 26 percent Sn.

Ag and 26 percent sn. Upon setting, the above specimens were found by x-ray diffraction to form γ_1 (Ag₂Hg₃) and γ_2 (SngHg) phases similarly to conventional amalgam. However, after storage at body temperature for 14 days, the γ_2 phase had disappeared. All diffraction peaks remaining could be related to the γ_1 phase.

The resulting amalgam (with single phase matrix) had a very high corrosion resistance. (Aided by NIH grant DE 02111).

RELATIONSHIPS BETWEEN INTERATOMIC FORCES AND ELASTIC CONSTANTS. R. A. Johnson. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The relationships between interatomic forces and elastic constants are available for the special cases of two-body central-forces applied to first and second nearest neighbors in fcc and bcc materials. The general case of non-central interactions applied to any crystal symmetry has been studied for a crystal model in which, in addition to explicit two-body interactions, there is a volume dependent contribution to the lattice energy. The relationships result from equating the change in energy in such a lattice model arising from an arbitrary displacement field to the energy stored in an elastic continuum under the same displacement field. Terms to second order in the displacement field are retained, while surface effects are neglected. (Supported by AEC Contract No. AT-(40-1)-3108)

COLLAPSE OF VOIDS IN STRESS FIELDS. R. A. Johnson and D. Kuhlmann-Wilsdorf. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Numerical computations were performed for the elastic energy associated with the stress field of a small elliptical hole in an isotropic elastic plate under a constant applied compression. The total energy of the system can then be written as a function of the a/b ratio of the ellipse, the orientation of the applied stress to the ellipse, the area of the ellipse, the thickness of the plate, the energy density at the surface of the ellipse, the elastic constants of the material, and the magnitude of the applied stress. Under appropriate conditions (large area of large stress), the elliptical hole, which can be thought of as a void in the material, will be able to decrease the free energy of the system by flattening and eventually collapsing. The collapse occurs by mass transport (surface diffusion), i.e. it is not a strain effect. (Supported by AEC Contract No. AT-(40-1)-3108)

COST OPTIMIZATION OF A POLYESTER-FILLER SYSTEM WITH PROPERTY CONSTRAINTS. W.C. Jones, III*, A.L. Fricke, and V.K. Natarajan*, Dept. of Chemical Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, VA. 24060.

Formulation of a filler-resin system for a particular application is a problem of minimizing costs of a system that will meet or exceed specified physical property limits, i.e., a problem of optimization with constraints, and the problem can be solved most efficiently if attacked as an optimization. As an example of the utility of the optimization approach, a five component polyester resin/filler system was studied in this work. A rotatable, central composite designed experiment, involving twenty-seven test formulations, was run to give five levels of each component. Properties were determined for each test formulation and equations relating properties to composition were developed by regression analyses. Using these as constraint equations with an objective cost function, we stated an optimization problem. Property limits were specified for particular applications as diverse as synthetic marble and synthetic wood, and the formulation was optimized to minimum cost for each application. The cost, composition, and estimated properties were calculated from the optimum for each application. The optimization also serves to indicate the active constraints for each application.

POLLUTION FREE, FLUXLESS PROCESSES FOR JOINING

POLLUTION FREE, FLUXLESS PROCESSES FOR JOINING ALUMINUM, D. A. Kaechele*, H. K. Herr*, Product Development Division, Reynolds Metals Company, Richmond, Virginia 23218.

Industrial corporations today have the responsibility and the technology to develop and use production processes which are consistent with our national goals of pollution free air and water. The dual challenge is keeping these processes economical so that increases in proprocesses economical so that increases in pro-

duction costs are nominal.

In traditional processes for brazing and soldering aluminum, fluxes are used. Their use generates air pollution in the form of fumes and water pollution from required post cleaning operations.

Reynolds Metals Company's Research Division has developed two new fluxless processes for joining aluminum: fluxless vacuum brazing and fluxless soldering. Both processes offer advantages from the standpoint of pollution control as well as other significant features. Reduced production costs, increased joint integrity, and elimination of potential corrosion factors make these processes extremely attractive. The general process procedures, materials and equipment are described in this paper.

SCANNING ELECTRON MICROSCOPE STUDIES OF THE OXIDATION OF TANTALUM. D.J. Kampe and K.R. Lawless, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22903

Scanning electron microscopy (SEM) in conjunction with transmission electron microscopy (TEM) and optical microscopy was used to study the initial stages of the oxidation of high purity (111) and (110) Ta single crystals and large-grained 5 mil thick sheet of approximately (001) orientation. The oxidations, performed at $530\,^{\circ}\mathrm{C}$ and 5×10^{-4} torr oxygen pressure, proceeded by the formation and growth of microscopic platelets.

TEM and selected area diffraction showed a cubic tantalum suboxide had formed in the {111} Ta plane while a twofold superlattice was present on the {001} Ta grains studied. Using SEM of surface oxide traces on two known planes, a {531} habit plane for the oxide platelets was determined.

A series of SEM micrographs of the same area

A series of SEM micrographs of the same area clearly establish that the platelets formed during the low oxygen pressure oxidations extend through the sample and are not solely surface phenomena. Samples oxidized at one atmosphere pressure showed a relatively uniform surface oxide, consisting of fine needles and transformed tantalum, with no internal oxide formation. (Aided by the Office of Naval Research).

THE COMPRESSIVE CREEP BEHAVIOR OF A Pu-1%Ga DELTA-STABILIZED ALLOY AT ELEVATED TEMPERATURES. J. L. Lytton, Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, A. D. Wheeler, W. L. Thayer, and J. L. Robbins, Lawrence Radiation Laboratory, Livermore, Calif.

Constant stress compression creep tests were performed in vacuum on a high-purity Pu-1 wt pct Ga δ -stabilized alloy over the temperature range from 252° to 382°C for stresses from 700 to 2600 psi. Although the primary creep behavior could not be correlated by established techniques, the creep rates developed after true creep strains of about 0.15 provided good agreement with the temperature and stress dependence of creep for pure metals and dilute alloys. A power stress law for steady-state creep of the alloy was found for σ/E values less than 5 x 10 $^{-4}$, with the stress exponent being 4.0, and it was concluded that the alloy exhibits Class I solid solution behavior. For higher stress, exponential stress dependence was observed. The true activation energy for creep was found to be 38,900 cal/mole which is in good agreement with the value for self-diffusion of Pu in the delta-stabilized alloy.

FRACTURE STUDIES IN SILVER WITH THE 500 kV ELECTRON MICROSCOPE. R. L. Lyles, Jr., and H.G.F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Thin, chemically grown, single crystals of Ag have been strained to fracture inside of the High Voltage Electron Microscope by means of a nydraulically loaded tensile stage. Direct observation and recording of the fracture process was accomplished by using a high performance image-intensifier video recording system in conjunction with the conventional photographic system. The characteristics of the fracture process were indicative of ductile fracture in bulk materials. Necking, shear, the formation of coalesence of holes, and the dislocation structure in the plastic zone preceding the crack have been observed and recorded. The silver ribbons had a (111) growth plane and the tensile axis was along the 110 direction. Accordingly, crack propagation took place 60° to the tensile axis along one of the two equally stressed glide planes, or the crack followed a zig-zag path with two glide planes active. (The sponsorship of the Office of Naval Research is gratefully acknowledged).

DISLOCATION CELLS. J. T. Moore and <u>D. Kuhlmann-Wilsdorf</u>, Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

In crystalline materials deformed under a great variety of conditions, the most prominent and most often occurring structural features are dislocation cells. According to the mesh-length theory of workhardening*, these cells are nature's means to reduce the long-range stresses of glide dislocations that are generated in the course of straining. In the same theory it is also assumed that the screening of the long-range stress fields of the dislocations is very effective in cells, while the dislocations' short-range stresses and line tensions remain largely unchanged. Due to the great complexity of the stress fields of dislocation cells, quantitative investigations to check on the above hypotheses had been lacking until recently when electronic computations of the stresses associated with various simple types of dislocation cells were carried out. The said hypotheses were indeed confirmed: The long-range stress field of dislocation cells was shown (i) to fall off as r-N with N the number of Burgers vectors represented in the cell and (ii) for a given shape and size of cell to rapidly decrease with increasing dislocation density. In all cases, the short-range stresses farther away than about one dislocation spacing from the nearest corner are very closely alike the short-range stresses of the corresponding infinitely extended disloca-

tion walls. (Supported by AEC Contract No. AT-(40-1)-3108)
*D. Kuhlmann-Wilsdorf, "Workhardening", (Eds. J. P. Hirth and J. Weertman, Gordon & Breach, N.Y.) 1968, pp 97-132

REDUCTION OF IRON FROM IRON-CONTAINING COMPOUNDS. <u>W. S. Moser</u>* and T. P. Floridis, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Additions of metallic iron have caused increases of the rates of reduction of iron from iron-containing compounds.

The investigated compounds were synthetic iron monticellite (CaO·FeO·SiO₂), fayalite (2FeO·SiO₂), and hercynite (FeO·Al₂O₃). The investigation was conducted at 900°C. The reducing agent was a mixture of 5% hydrogen and 95% nitrogen. The rates of reduction were determined by continuous weight-loss measurements.

Additions of 10% iron powder to iron monticellite, fayalite, and hercynite have caused increases in their initial rates of reduction by 150, 15, and 97 percent, respectively.

(Financial support by the American Iron and Steel Institute is gratefully acknowledged.)

STRAIN ENERGY CONSIDERATIONS FOR THE FCC-BCC TRANSFORMATION IN THIN IRON FILMS PSEUDOMORPHICALLY GROWN ON (001) COPPER SUBSTRATES. G. H. Olsen and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The orientations of bcc iron precipitates which formed from the surrounding fcc matrix in thin 001 iron deposits on copper have been determined to be variants of the Pitsch, and Kurdjumov-Sachs orientation relationships. These orientations were observed to favor those of the Pitsch type, as the iron overgrowth thickness increased. A rationalization of the above results is made in terms of elastic strain energy associated with the formation of a precipitate in an iron matrix subjected to plane stress by the copper substrate. It is shown that the observed orientations correspond to low elastic strain energy. Similar energy arguments are shown to successfully explain similar orientation observations reported earlier for bcc precipitates in iron deposits grown on 001 nickel substrates. An iron matrix is in tension on its copper substrate but is in compression on a nickel substrate. The observed orientations of the bcc precipitates are different in the two systems. However, the orientations observed in both systems are those having low elastic strain energy. (Supported by AEC Contract No. AT- (40-1) -3108)

PHYSICAL ADSORPTION PHENOMENA OCCURRING IN SPACE-LIKE ENVIRONMENTS. R. A. Outlaw,* NASA-Langley Research Center, Hampton, Va. 23365, and J. P. Wightman, Dept. of Chemistry, VPI&SU, Blacksburg, Va. 24061

Physical adsorption isotherms of nitrogen gas on chemically cleaned Pyrex glass have been dynamically determined in the pressure range of 1 x 10^{-11} to 1 x 10^{-7} torr (N_2) and at temperatures of $77.4^{\mathrm{O}}\mathrm{K}$ and $87.5^{\mathrm{O}}\mathrm{K}$. A study has been made of the variation equilibrium time with the pressure above the adsorbed layer. Data is presented to show the fit to the Dubinin-Radushkevich equation. Extrapolation of this data indicates that the surface area of the chemically cleaned Pyrex is about twice that of Pyrex not chemically cleaned. Calculated isoteric heats indicate an average heat of adsorption of 6 kcal/mole over the range of coverage studied. Finally, data is presented which shows that the log of the equilibrium time varies linearly with the log of the pressure above the adsorbed layer.

EFFECT OF SUBBOUNDARY PINNING BY γ^1 PLATELETS ON THE CREEP BEHAVIOR OF AL-0.5 AT.% Ag. P. G. Pawar and J. L. Lytton, Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Heterogeneous precipitation of $\boldsymbol{\gamma^{\text{I}}}$ platelets on dislocation networks has been developed as a means of imparting increased strength and thermal stability of subgrain structures through effective pinning. Age hardening curves for Al-0.5at. Mg at 200°C have revealed that peak hardness is obtained in specimens aged for about 100 hrs. Constant stress tensile creep tests have been conducted at 200°C and 3000, 4000, 6000, and 8000 psi for specimens with different prior thermal-mechanical treatments. Specimens given a solution heat treatment at $400^{\circ}\mathrm{C}$ for 10 hours followed by 5 pct. prestrain, recovery annealing at 300°C for 15 min., and 100 hrs. aging at 200°C have been found to develop rather well defined subgrains pinned by γ^\prime precipitation. Specimens which were solution heat treated and aged for 6 hrs. at 200°C prior to creep testing proved to have a lower steady-state creep rate than those containing subgrain structures with γ' platelets pinning the subboundaries after 100 hrs. aging at 200°C. Transmission electron microscopy revealed that this was the result of generation of a fine and uniformly distributed array of $\boldsymbol{\gamma}$ platelets in the solution treated and aged structure. pears from the study made so far, that the morphology of the precipitate structure plays a more important role than the subgrains in governing the creep strength at elevated temperatures. (Aided by NSF Grant Gk-10972)

INCREASE OF TECHNICAL STRENGTH OF MECHANICALLY GRIPPED FIBERGLAS RODS BY SURFACE TREATMENT. K. Reifsnider and C. Kelley*. Dept. of Eng. Mech., Va. Polytechnic Inst., Blacksburg, Va. 24061

Epoxy-matrix fiberglas rods were pulled to fracture in simple tension using standard conical chuck cable grips with serrated gripping surfaces. Failure of the rods always initiated in the grip area. A number of specimens was soaked in a special solution for a short period of time prior to testing. The technical strength of the treated specimens was from 10-15% greater than the untreated ones. The increased toughness and ductility of the treated surface is thought to "blunt" the stress distribution by material flow in the areas of concentration created by the mechanical grips. In particular, the initiation and propagation of cracks is inhibited by this solution softening of the gripped surface area. (Aided by DoD Project THEMIS, Contract No. DAA F07-69-C-0444.)

SOME FUNDAMENTAL INTERACTIONS BETWEEN PROTEINS AND SURFACES. G. E. Stoner. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

The first measurable act of the interaction between a cardiovascular prosthetic material and blood is the adsorption of one of the plasma proteins, fibrinogen. The mechanism of this act of adsorption, as well as its prevention (or inhibition) in some cases, is related to the surface charge excess of the material and the amino acid residues (R-groups) of the adsorbing protein molecule.

A theory of selective protein adsorption, and its relationship to a material thromboresistance and general "compatibility with blood" is presented. (Aided by NIDR grant USPHS DE 02111-07).

USE OF AN ENERGY DISPERSIVE X-RAY SPECTROMETER ON A SIEMENS TRANSMISSION ELECTRON MICROSCOPE. R. L. Trent and W. A. Jesser. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

An ortec energy-dispersive X-ray spectrometer employing a Si(Li) detector of 163 eV resolution at 5.9 keV and designed for use on a Cambridge scanning electron microscope has been interfaced to a Siemens transmission electron microscope by attaching it through one of the stereo tilt access ports. Some details associated with viewing a specimen elevated in the field of the objective lens so as to have a direct line of sight to the X-ray detector are discussed. Use of the instrument in quantitative analysis of bicrystal systems is presented. (Supported by AEC Contract No. AT-(40-1)-3108)

INFLUENCE OF ORIENTATION ON DIFFUSION IN POLYMERS. R.C. Tsai and R.E. Barker, Jr., Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

Argon transport in the uniaxially oriented films of a random copolymer of methyl methacrylate and ethyl methacrylate has been studied. The degree of orientation was characterized macroscopically and by measurement of optical birefingence. The effect of varying degrees of orientation on permeation and diffusion of argon in polymer films was determined by the time-lag method using a mass-spectrometer to obtain gas pressure as a function of time.

The orientation process transforms the polymer from a random array of coiled molecules toward a quasi-crystalline arrangement with a consequent increase in activation energy. Surprisingly, the diffusion and permeation coefficients were observed to decrease significantly in highly elongated films. The observed phenomena have been interpreted in terms the correlated interchange of configurational and activation entropy. It is proposed that the dynamical configuration is virtually the same for both the oriented and the unoriented material, so that the entropy difference between the normal state and the activated state must increase as the elongation increases. Some new results in support of this hypothesis will be discussed. (Aided by NIDR Grant No. DE-02111).

A STUDY OF THE PROPERTIES OF SILVER AMALGAMS CONTAINING VARYING AMOUNTS OF TIN. <u>F.E. Wawner, Jr.</u> and K.R. Lawless. Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

A study has been conducted to characterize Ag-Sn-Hg alloys with respect to various physical and mechanical properties. Amalgams containing 0, 4.3, 8.3, 12.0, 15.4, 18.5, 21.4, and 24.1 atomic percent tin were prepared by two different techniques; normal trituration and condensation, and by hot pressing. Properties such as structure, strength, expansion, fracture, and corrosion were investigated and correlated. The study showed that maximum expansion in the alloys could be associated with internal voids and consequently minimum strength and vice versa. Fracture in the low tin content alloys was predominately intergranular whereas for the normal amalgam inter- and intragranular fracture were observed.

Under certain preparation conditions (hot pressing), dental amalgam could be prepared without the $\mathrm{Sn}_{\,\,7}\mathrm{Hg}$ phase which led to a much less corrosive material.

COMPUTER GENERATED KIKUCHI MAPS FOR FCC, BCC, DIAMOND CUBIC, AND HCP CRYSTALS. C. T. Young and J. L. Lytton, Dept. of Metals and Ceramic Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In order to eliminate the tedious calculations required to index Kikuchi patterns, computer programs have been developed to provide for computer plotting of standard stereographic Kikuchi projections, i.e., Kikuchi maps, of any desired orientation and any desired projection sphere radius for FCC, BCC, diamond cubic, and HCP crystals. The programs also provide for identification of Kikuchi poles, either printed on the map or a separate sheet, as well as identification of individual Kikuchi lines. Indexing of patterns then becomes a matter of comparison between observed patterns and the Kikuchi maps. This is particularly helpful in the study of HCP crystals. Coates patterns obtained from scanning electron microscopy as well as x-ray Kossel patterns can also be generated simply by changing the input wave length. (Aided by NSF Grant CK-10972)

Section of Medical Sciences

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12—14, 1971, Blacksburg, Virginia

MEASUREMENT OF HYDROGEN PEROXIDE BY FLUORESCENCE.

R. B. Brandt and M. J. Black*. Dept. of Biochem., Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219
Diacetyl-dichlorofluorescin (LDADOF), a stable

Diacetyl-dichlorofluorescin (LDADCF), a stable nonfluorescent compound, was synthesized from the highly fluorescent compound 2',7'-dichlorofluorescein (DCF) [Brandt, R. and Keston, A., Anal. Blochem., 11, 6 (1965)]. Activation of LDADCF by hydrolysis in 0.01M sodium hydroxide yields a compound that can be oxidized to DCF with hydrogen peroxide by enzyme catalysis with horse radish peroxidase (HRP). Fluorescence measurements were made using an Aminco-Bowman Spectrophotofluorometer. The activation and fluorescence maxima of DCF were measured at different pH's to determine the pH for optimal fluorescence. Incubation at 37°C for 15 minutes with activated LDADCF and HRP in phosphate buffer, pH 7.0, together with varying amounts of hydrogen peroxide produced fluorescence that was measured at 525 nm, when excited at 475 nm. From the plot of apparent fluorescence vs. [H2O2], the reaction appears to yield two moles of DCF per mole of hydrogen peroxide.

SKELETAL MUSCLE DEGENERATION PRODUCED BY LOCAL ANESTHETICS.

G. W. Burke, Jr.*, J. R. Fedison, and C. R. Jones. Med. Col.
of Va., Va. Commonwealth Univ., Richmond, Va. 23219.

Both masseter muscles of 20 golden hamsters and tongues

of 90 rats were injected with a 0.1 ml. amount of one of the following agents: 2% Lidocaine, 1% Procaine, 1% Tetracaine, 0.1% Tetracaine, and isotonic saline. None contained epinephrine. Previous work indicated that neither Procaine nor isotonic saline produced skeletal muscle degeneration and thus served as control. Following injection animals were sacrificed at 1/2, 1, 4-5, 8-9, and 30 days. Injected muscles were removed and fixed in 10% neutral buffered formalin. Tissues were processed for sectioning serially at 5-7 micra and stained with H & E. Injections of Lidocaine and Tetracaine produced severe degeneration of skeletal muscle in all instances. Early response indicated a loss of striation, pycnosis of nuclei, and acute inflammatory reaction. was progressive loss of myofibrils and shrinkage of the diameter of individual fibers. In some instances completely empty sarcolemma sheaths were observed. Early stages of regeneration were evident in 4-5 days specimens. Numerous and large pale staining nuclei appeared in the center of shrunken muscle fibers. The sarcoplasm exhibited an enhanced basophilic staining reaction. Regeneration was completed in most instances by the end of 30 days. When the concentration of Tetracaine was reduced to 0.1% muscle lesions were less severe and confined to smaller areas. No skeletal muscle degeneration occurred in any of the control animals.

EFFECTS OF VARIOUS LIGHTING REGIMENS ON HAMSTER PINEAL-GONADAL INTERACTION IN A CONTROLLED ENVIRONMENTAL CHAMBER. J. W. Clabough and S. F. Cleary. Depts. of Anatomy and Biophysics, Med. Col. of Va., Richmond, Virginia 23219

Light deprivation for 4-6 weeks results in pineal-induced gonadal atrophy in adult golden hamsters, whereas constant light impedes pineal antigonadal activity. In mammals, information about environmental lighting is transmitted to the pineal via a pathway which includes the eyes, optic nerves, central connections, and cervical sympathetics. Recently, 0'Steen (Anat. Rec. 169:392) reported that albino rats which were housed in constant light (18 ft-c) for 30 days exhibited nearly complete degeneration of the retinal photoreceptor cell layer and were, in effect, blind.

photoreceptor cell layer and were, in effect, blind.

The present studies were designed to test the effects of various lighting intensities (600, 18, 0.1 and 0.01 ft-c) on the retinas and pineal-gonadal axes in adult white male hamsters. The following data were obtained from animals housed for 6 weeks in specially constructed, constant temperature chambers equipped with cool white fluorescent light sources: 1) constant darkness resulted in pineal-induced gonadal atrophy; 2) constant light (600 ft-c) did not appear to alter testicular function or produce marked retinal degeneration; however, thickness of the photoreceptor cell outer segment layer was reduced; 3) very low intensities of constant light (0.1 and 0.01 ft-c) produced variable testicular atrophy indicating that there may be a light intensity threshold below which constant light does not inhibit pineal antigonadal activity.

PHYSIOLOGICAL TRANSPORT IN RELATIONSHIP TO AGING. J. L. Gainer and <u>G. M. Chisolm*</u>, Dept. of Chemical Engineering, Univ. of VA, Charlottesville, VA 22901.

It has been recently demonstrated that the diffusivity of oxygen, glucose and carbon dioxide through blood plasma decreases markedly with increasing plasma protein concentrations within the "normal" concentration ranges. For example, increasing albumin concentration in plasma from 2.0gm/100ml to 5.0 gm/100ml decreases oxygen diffusivity by 50%. Since the concentrations of albumin, the globulins as well as cholesterol, change with various pathological conditions and with aging of "normal" subjects, it is possible that the subsequent changes in diffusion may have physiological consequences.

In this study, resulting changes in diffusivity with increasing age were examined analytically. To find the change in plasma protein with age, data were obtained from previous studies of healthy human subjects. Scatter diagrams were then made showing mean concentrations of albumin, gammaglobulin, fibrinogen and cholesterol vs. age. Plots were made of those showing definite trends. These plots were fit with least-squares polynomicals. These results were then used to predict changes in diffusivity through plasma with age.

of those showing definite trends. These plots were fit with least-squares polynomicals. These results were then used to predict changes in diffusivity through plasma with age.

The results indicate a significant decline in diffusivity with age. It is possible that hypoxia resulting from the lowered diffusivity of oxygen might be a contributing factor to physiological changes usually associated with aging such as memory loss or atherosclerosis.

THE EFFECT OF SOCIAL STRESS ON AVIAN TUMORS AND OTHER INFECTIOUS DISEASES. <u>W. B. Gross</u> and G. Colmano, Dept. of Veterinary Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Chickens were kept in a high stress (HS) social environment by transferring them at least twice per week to cages containing unfamiliar chickens of the same sex. Chickens were kept in a low stress (LS) social environment by maintaining them for at least 2 weeks prior to experimental procedures in cages with 1 or 2 birds or in the dark.

HS chickens were more susceptible to viral infections, (including virus induced tumor), less susceptible to bacterial infections and produced less antibodies than LS birds. Chickens selected for a high plasma corticosterone reaction to stress were more susceptible to viral infections, less susceptible to bacterial infections and produced less antibody than chickens selected for a low plasma corticosterone reaction to stress. The feeding of adrenal blocking chemicals such as metyrapone or DDD resulted in increased resistance to viral infections. Doses of DDD which were higher or lower than the optimal dose were less effective. The injection of adrenocorticotrophic hormone or corticosterone resulted in increased resistance to bacterial infections. (Aided by NIH grant AIO8978)

MORPHOLOGY OF THE MALE REPRODUCTIVE TRACTS OF THE LESSER BUSHBABY (<u>GALAGO</u>) AND THE TREE SHREW (<u>TUPAIA</u>). <u>William G. Dail</u>, <u>Jr</u>. Department of Anatomy, Med. Col. of Va., Richmond, Virginia 23219

A comparative study was made of the male genitalia of <u>Galago</u> and <u>Tupaia</u>. <u>Galago</u> differs from <u>Tupaia</u> by having an os penis and permanently descended testes. The testes in <u>Galago</u> are located in a parapenial position whereas the testes of <u>Tupaia</u> are anterior to the penis.

The vas deferens of <u>Tupaia</u> has a terminal enlargement, the ampulla. There is no ampulla in <u>Galago</u>. The seminal vesicles of <u>Galago</u> are simple tubular sacs which open into the urethra. In <u>Tupaia</u> the seminal vesicles are lobulated and drain into the vas deferens. The prostate of <u>Galago</u> is a large compact mass, absent only on the anterior surface of the urethra. The prostate of <u>Tupaia</u> is small delicate with wing-like dorsolateral projections and a small median dorsal lobe. Both animals have typical tubuloacinous bulbourethral glands. The bulbourethral glands in <u>Galago</u> share a common excretory duct.

The significance of these findings is discussed on a comparative basis.

THE EFFECTS OF PINEALECTOMY AND BLINDING IN THE ADULT "P E T" MOUSE. <u>Joseph C. Gregorek</u> and Hugo R. Seibel, Department of Anatomy, Med. Co. of Virginia 23219.

The pineal gland is believed to produce an antigonadotrophic substance, and to be activated by the absence of light in the adult hamster and rat. Blinding in these animals results in a decrease in the size of the testes, but simultaneous pinealectomy of these animals will inhibit this response.

Seven experimental groups of adult "PET" mice received the following surgical procedures: hemicastration, blinding, pinealectomy, pinealectomy-hemicastration, pinealectomy-blinding, hemicastration-blinding and pinealectomy-hemicastration-blinding.

Preliminary studies indicate that blinding in the adult "PET" mouse does not marketly affect testicular size under the conditions of the present experimental set-up. Hemicastration, pinealectomy, pinealectomy-hemicastration, and hemicastration-blinding slightly increase testicular weight. Pinealectomy-blinding, and pinealectomy-hemicastration blinding also cause an increase in testicular weight. The above results will be discussed.

IN VITRO FERTILIZATION OF CAT (FELIS CATUS L.) EGGS. C. E. Hamner, L. L. Jennings* and N. J. Sojka, Div. of Reproductive Biology, Dept. of Obstetrics and Gynecology, Univ. of Virginia School of Med., Charlottesville, Va 22901.

Recently ovulated cat eggs can be fertilized in vitro by cat spermatozoa that have been incubated in the uterus of estrus females for 2 to 24 hours. There was no cleavage of any egg cultured without spermatozoa or with freshly ejaculated spermatozoa. A total of 80 eggs were cultured with spermatozoa that had been incubated in utero for 2 to 24 hours. Fifty eggs or, 62 5% of the total, were fertilized. The fertilized eggs cleaved normally up to the 8-cell stage in heated rabbit blood serum before arrest of development. (Aided by NICHHD Grant no. HD-03516).

REJECTION OF SKIN ALLOGRAFTS IN THE NEWT, NOTOPTHALMUS VIRIDESCENS, WITH SPECIAL REFERENCE TO THE EFFECTS OF PHY-TOHLMAGGLUTININ. J.A. Hightower*, Dept. of Anatomy, Med.

Col. of Va., Richmond, Va. 23219 Surface morphology and histological sections of skin allografts were studied in untreated adult newts and compared with allografts from newts receiving Phytohemagglutinin (PHA) either before or after grafting in an effort to determine whether PHA caused alterations in the events leading to and including complete allograft rejection. In addition, the morphology of spleens, thymuses, livers, bone marrows and intestines from untreated and PHA-treated newts were studied and compared to determine whether PHA or allografting caused alterations in the cellular composition of the hemopoietic tissues of normal adult newts.

The results obtained in this study indicated that the administration of PHA did not affect the time of complete allograft rejection or alter the cellular composition of the thymus, liver, bone marrow and the lamina propria of the intestine. However, the administration of PHA did cause an increase in the number of lymphocytes and the destruction of erythrocytes in the spleen of the newt.

As a result of a detailed study of many grafts in various stages of rejection, it was determined that hemal stasis within allografts was a more reliable indicator of complete

graft rejection than death of melanocytes.

A POSSIBLE EXPLANATION CONCERNING THE ACTION OF HEMOGLOBIN S AT THE MOLECULAR LEVEL. William Keefe. Department of Biophysics, Med. Col. of Va., Richmond, Va. 23219.

A program has been written based on the theories of Ramachrandran and Scheraga which will make it possible to choose the most probable configuration of a polypeptide chain. This will be used on the first six amino acids in the beta chain of normal and S hemoglobin to determine what structural differences, if any, there are between these two hemoglobins.

THE ENIGMA OF THE RATTLESNAKE'S RATTLE. James H. Martin*.

Dept. of Physiology, Med. Col. of Va., Richmond, Va. 23219
The "use" or "function" of the rattlesnake's rattle has been a source of active discussion since the discovery of the rattlesnake. Although the precise techniques of modern physiology cannot determine "the use" of the rattle, they can determine how the rattle mechanism functions. presented indicate that the systems generating the rattle motion may be unique for vertebrate skeletal muscle.

The maximum rattling frequency is a linear function of temperature between 16° and 32°C. The rattling motion is a complex wave form rather than the described sine wave. There is a maximum frequency which is dependent on temperature,

is a maximum frequency which is dependent on temperature, and a "preferred" rattling frequency which is additionally dependent on tail and rattle mass.

The muscles producing the rattling motion do not normally give graded or tetanic responses. All the fibers twitch with an "all or none" response, much like a heart. The twitch is explusive temperature fast, and at 18°C, the contraction time is cally 10 means. is only 10msec.

The in situ length of the fibers allows for only $^2/^3$ the possible tension to be generated. A strip of muscle must be stretched to a length 50% greater than the in situ rest length before the peak is reached on the length-tension curve. At that point, the tension developed is only about 0.3kg/cm², a tension considerably less than that developed by most skeletal muscles.

Supported by NSF grant GB-8685

ADDITIONAL ROUTES IN THE METABOLISM OF NICOTINE TO 3-PYRIDYL-ACETATE. R. H. Meacham, Jr., E. R. Bowman, and H. McKennis, Jr. Dept. of Pharmacology, Med. Col. of Va., Richmond, Va.

The metabolism of dihydrometanicotine and metanicotine, two minor alkaloids of tobacco smoke, has been studied in Following intravenous administration of dihydrometanicotine difumarate (84.6 mg/kg) to male mongrel dogs. the urine was processed to obtain 4-(3-pyridy1) butyric acid and 3-pyridylacetic acid, which were isolated as methyl esters and identified by melting points, elemental analyses, and the infrared spectra of their picrate derivatives. After intravenous administration of metanicotine (35 mg/kg) to male mongrel dogs, 4-(3-pyridy1)-3-butenoic acid and 3-pyridylacetic acid were isolated as methyl esters by processing the collected urine. Methyl 4-(3-pyridyl)-3-butenoate was identified by NMR and mass spectrometry, and by elemental analysis of its picrate derivative. Methyl 3-pyridylacetate picrate was identified by melting point, elemental analysis, and its infrared spectrum. Previous studies (McKennis, Schwartz, and Bowman, 1964) have provided evidence for the metabolic formation of 3-pyridylacetic acid from (-)-nicotine via either (-)-cotinine or (-)-demethylcotinine. of the report of Truhaut and De Clercq that dihydrometanicotine is a metabolite of nicotine in the rat, a third alternate route to 3-pyridylacetate is suggested by the present investigation. (Aided by grants from the American Tobacco Co. and the AMA-Education & Research Foundation.)

THE ISOLATION AND CHARACTERIZATION OF RNA FROM NORMAL AND REGENERATING RAT LIVER. C.H. O'Neal Dept. of Biophysics, Med. Col. of Va., Richmond, Va. 23219

The regenerating liver system is an example of a mitotically inactive organ that can be induced to undergo cellular proliferation within a known time sequence. It is therefore an ideal system to demonstrate whether or not t-RNA "modulation" has a role in the regulation of transcription and translation in a mammalian system. Techniques for rapidly performing the partial hepatectomy, isolation of the nucleic acid fraction, and particularly the isolation, characterization and assay of t-RNA will be described.

It has been found necessary to include detergent in all steps of the isolation to inhibit the effect of nuclease. The usual procedure for separation of t-RNA from ribosomal RNA with 1M NaCl has not been found to be satisfactory. Conditions for BD cellulose chromatographic fractionation of t-RNA in one mg amounts have been developed for examination of material from single livers. Preliminary studies with P32 and S35 will be described. (Supported by N.S.F. grant GB 14046)

SILICONE RUBBER TECHNIC FOR THE STUDY OF RENAL AND HEPATIC MICROCIRCULATION. <u>J. Clark Osborne</u>[†] and J. H. Meredith. Dept. Surg., Bowman Gray Sch. Med., Wake Forest Univ., Winston Salem, N. C. 27103

August Krough pioneered direct visualization of small vessels in vivo by transillumination technics. This technic was limited when one wished to study capillaries in thick parenchymatous organs. A silicone product (MICROFIL, Canton Bio-Medical Prod., Inc., Denver, Colo. 80239) has recently become available for perfusing the microvasculature and other tubular structures. The composition, characteristics, and mixing instructions are shipped with the product.

Approximate volumes were obtained by measuring the amount of saline required to empty blood from the arteries or veins of organs under study. Injections were made manually after pressure "feel" was established by training trials using a mercury manometer. The aim was not to exceed 1 1/2X physiological pressures. The liver was perfused with yellow, orange, white and maroon into the bile ducts, portal vein, hepatic artery and hepatic vein, respectively. cleared, study with a stereoscopic microscope revealed many lobes perfused in an excellent fashion for detailed study. Histological sections may be made from the perfused tissue through the program of the program o

Va. 24061

SOME STUDIES ON THE ENZYME ORNITHINE DECARBOXYLASE. Walter B. Panko* and Francis T. Kenney*, Dept. of Urology, Univ. of Va. Sch. Med., Charlottesville, Va. 22901, and Biology Div., Oak Ridge Nat. Lab., Oak Ridge, Tenn. 37830

Hepatic ornithine decarboxylase activity in adrenalectomized rats was increased by a variety of hormones, including hydrocortisone, growth hormone, insulin, glucagon, and thyroxin. Repeated treatment with either hydrocortisone or growth hormone, the most effective of the hormones tested, failed to maintain the elevated enzyme levels attained within a few hours after the initial injection. A partial purification of the induced hepatic enzyme was accomplished. (Research jointly supported by the Nat. Cancer Inst., NIH and the U.S. Atomic Energy Commission under contract with Union Carbide Corp. and NIH Grant FR05431-10)

DNA SYNTHETIC AND MITOTIC ACTIVITY OF DIFFERENTIA-TING LENS CELLS IN THE CHICK EMBRYO. T.L. Pearce. Dept. of Anatomy, Sch. of Med., Georgetown Univ., Washington, D.C. 20007

A combined immunofluorescence-autoradiography technique was applied to the embryonic chick lens placode to determine whether cells which had begun biochemical differentiation were still capable of DNA synthesis or division. Embryos were given 5 μc tritiated thymidine in ovo at 50 h. of incubation and harvested 4 h. later. Sections were treated first for immunofluorescence then submitted to autoradiographic procedures. By comparing the same lens sections treated with both techniques it was possible to tell which cells had synthesized both lens crystallins and DNA, and which had undergone division after crystallin syn-From stage 14, when crystallins first apthesis. pear, through stage 16 no significant change was seen in the DNA synthetic or mitotic rates from pre-crystallin levels. Fluorescence spread to 85% of cells during this time. In stage 16, 41% of cells were labeled with both fluorescence and autoradiographic grains. These results and the observation of a number of fluorescent mitoses indicate that the onset of crystallin synthesis precludes neither DNA synthesis nor division in this tissue. (Supported by NIH grant GM39,219)

THE RESPONSE OF RAT THYMUS NUCLEI TO THYROID HORMONE Edwin Ruark* and C.J. Ackerman, Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061

The effects of triiodothyronine (L-T₃) on the protein, RNA and DNA fractions of the thymus nuclei of growtharrested sulfaquanidine-fed rats has been studied. A single injection of 15 µg of L-T, stimulated the incorporation of ¹⁴C-labelled amino acids into total nuclear protein, whole histone, and histone fractions. Time course studies indicated that the protein & RNA moieties of thymus chromatin of rats were increased after the administration of L-T₃. This change is accompanied by an increase in the template efficiency of the chromation. The naked DNA is not affected by L-T $_3$. The results suggest that L-T $_3$ has a direct effect on rat thymus chromatin which enhances its potential as a template for RNA synthesis.

TRYPTOPHANYL FLUORESCENCE OF SODIUM DODECYL SULFATE-TREATED AND 2-MERCAPTOETHANOL-REDUCED PROTEINS: A SIMPLE ASSAY FOR TRYPTOPHAN. K. R. Shelton and K. S. Rogers. Dept. of Biochemistry, Med. Col. of Va., Health Sciences Div. of Va. Commonwealth Univ., Richmond, Va. 23219 Relative tryptophanyl fluorescence intensities of eleven

different proteins (bovine liver glutamate dehydrogenase, bovine pancreas trypsin and α -chymotrypsinogen, egg white lysozyme, ovalbumin, bovine serum albumin and γ -globulin, bovine heart and rabbit muscle lactate dehydrogenases, rabbit muscle glyceraldehyde-3-phosphate dehydrogenase, and yeast alcohol dehydrogenase) were evaluated as a function of the physical state of the protein, <u>i.e.</u> native, denatured with intact disulfide bonds, and denatured with reduced disulfide bonds.

Tryptophanyl fluorescence of these proteins was directly proportional to the tryptophan content of the reduced, detergent-protein complex. Denaturation of proteins by detergent alone, although causing pronounced changes in fluorescence intensity, was unable to provide a common microenvironment for all tryptophan residues. A simple fluorescence assay of tryptophan content in proteins was developed.

THE CHARACTERIZATION OF PROTEIN FROM NORMAL AND REGENERATING RAT LIVER BY S.D.S. ACRYL-AMIDE GEL ELECTROPHORESIS. M. Thompson and C. O'Neal Dept. of Biophysics, Med. Col. of Va., 23219

Gel electrophoretic techniques offer considerably greater resolution for the analysis of macromolecules than standard procedures. The techniques of agarose slab, standard disc and S.D.S. gel electrophoresis have been used to examine the plasma and 30,000g supernatant from normal and regenerating rat livers at different time periods following partial hepatectomy. The patterns were examined to detect variations between individuals and for any marked quantitative or qualitative differences during regeneration. Various techniques for staining the gels will be described including the fluorescent ANS procedure. The S.D.S. gel technique offers the further advantage of molecular weight estimation.

Gel fractionation of nucleic acid samples from normal and regenerating tissues will also be described. (Supported by N.S.F. grant GB 14046 and an A.D. Williams Award)

THE INHERITANCE OF TONGUE ROLLING AND FOLDING. Martha R. Yancey* and J. I. Townsend. Program in Human Genetics, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219

The ability of 1040 Caucasian college students to turn up

the tip of the tongue varies from not at all to folding the organ flat upon itself. The ability to roll the margins of the tongue upward appears to be inherited independently of the ability to fold the organ, but only if folding is classified as folding the tip flat upon the organ. The results of this study are consistent with previous reports of determination of the ability to roll the tongue by an autosomal dominant gene and of ability to fold, by an autosomal recessive gene. The frequencies of these genes in the present sample are in close agreement with frequencies in other Caucasian populations, but differ to various extents from those reported in other races.

Section of Microbiology

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12—14, 1971, Blacksburg, Virginia

DRUG RESISTANCE IN <u>PSEUDOMONAS AERUGINOSA</u>. <u>Ruth B. Finley*</u> and J. D. Punch, Dept. of Microbiology, Health Sciences Division, Va. Commonwealth Univ., Richmond, Va. 23219.

Division, Va. Commonwealth Univ., Richmond, Va. 23219.

The ability of <u>P. aeruginosa</u> to serve as an R factor host has been investigated. Attempts to transfer R factor 222 from Escherichia coli, Proteus mirabilis, and Salmonella typhimurium to P. aeruginosa recipients, to transfer drug resistance from 24 multiply resistant clinical isolates of E aeruginosa to <u>E. coli</u>, and to eliminate drug resistance in \overline{P} . aeruginosa cultures by acridine treatment have not been suc-During the analysis and characterization of the DNA from 12 multiply resistant isolates of P. aeruginosa, extrachromosomal bands were observed in the DNA from strains. Satellite DNA bands from one strain had buoyant densities of 1.718 and 1.711 g/cm 3 in CsCl. Buoyant densities after thermal and alkaline denaturation indicated that both bands were composed of double-stranded DNA; the heaviest band was present as covalently closed circular molecules, and the other as linear DNA molecules. The extrachromosomal bands observed in the DNA from the other strain had buoyant densities of 1.711 and 1.705 g/cm3; both molecular species were composed of linear double-stranded DNA. The inability to transfer R factors to P. aeruginosa and to transfer drug resistance from clinical isolates suggests that R factors contribute little, if any, to the multiple resistance so characteristic of this species. This study provides, however, the first report of satellite DNA bands in P. aeruginosa.

ANTIGENIC STUDIES OF RABIES ISOLATES. Martha Hale and Philip H. Coleman, Dept. of Microbiology, MCV-HSD, Virginia Commonwealth University, Richmond, Virginia.

In the United States rabies occurs primarily as an enzootic disease of wild animals with distinct, host-related, geographic patterns of distribution. The present studies were initiated to determine if viruses isolated from naturally infected wild animals in one area of the country could be distinguished antigenically from isolates obtained in other areas or from vaccine strains. Serological antigens were prepared from suckling mouse braims infected with "street" rabies isot lates obtained from foxes, skunks, bats, and raccoons and from "Low Egg Passage" (LEP) and "Challenge Virus Strain" (CVS) vaccine strains. Hyperimmune ascitic fluids were prepared in mice and serologically tested against homologous and heterologous antigens. In micro-Ouchterlony gel diffusion and complement fixation tests, differences were detected between the vaccine viruses and the field isolates and between some of the field isolates.

THE PROTECTIVE EFFECT OF IMMUNE SERUM IN MURINE SALMONELLOSIS. Nelda M. Marecki* and H. S. Hsu Dept. of Microbiology, Med. Coll. of Va., Richmond, Va. 23219

There have been conflicting reports concerning the ability to protect mice against lethal salmonella infection by presensitization of the organism with normal or immune serum. In the present study, serum from guinea pigs or mice infected with Salmonella typhimurium was used. Suspensions of virulent S. typhimurium (8x104/ml) were mixed in equal volume ratio with normal or immune serum and incubated for 15 mins at room temperature. Serial dilutions were made to yield suspensions containing 10^3 , 10^2 and 10 organisms per 0.5 ml for intraperitoneal injection into mice. This treatment of bacteria with serum was not bactericidal as determined by viable bacterial counts. The following observations were made: the $\rm LD_{50}$ in mice for this strain of salmonella was approximately 10 bacteria by ip route; presensitization of bacteria with normal serum did not alter the percentage of sur vival of infected mice; the presence of immune serum offered significant protection against fatal infection when the challenge doses were 10 or 10 bacteria. It was concluded that humoral factors played a benefitial, but not a decisive, role in acquired resistance in salmonellosis.

TUPLUENCE OF THE FLA PHENOTYPE ON THE FUNDENCY OF FIRRIATE THE BLUENTS IN ESCHEARING COLI K 12. A.S. Markusen and Frank Osborne. Christopher Newport College, Newport News, Virginia 23606 and the Department of Biology, Rensselaer Polytechnic Institute, Troy, New York 12181

Genes controlling the Fim and Fla phenotypes are

mapped widely separated loci on the <u>E. coli</u> linkage map but certain anomalies appear in the linkage data when <u>fim</u> is transferred as an unselected marker in conjugation experiments.

A system is described in which the outcome of crosses between a fim donor and a fim recipient was influenced by the Fla phenotype of the recipient strain. When variants of a fim fla recipient that had reverted to fla were used as genetic recipients in crosses with a fim donor, the frequency of resulting Fim recombinants as well as the readiness with which the Fim phenotype were expressed was increased. (Aided by grant 20-0297A from the Research Foundation of the State of New York)

STUDIES ON Naegleria sp. AND EXPERIMENTAL PRIMARY AMOEBIC MENINGOENCEPHALITIS. E. Clifford Nelson and Muriel M. Jones, Dept. of Microbiology, Med. Col. of Va., Richmond, Va.

At least 16 cases of fatal amoebic meningoencephalitis have occurred in Virginia since 1937 (Santos, 1970). From the last four occurring in the summers of 1967, 1968 and 1969 we isolated strains of an amoeba-flagellate belonging to the genus Naegleria. These strains have proven highly pathogenic for mice inoculated by simple nasal instillation.

Present evidence indicates that human infections arise when amoebae growing in fresh water are introduced during swimming or splashing in water. In an effort to pin-point the environmental origin of the pathogenic strains we are making isolations of Naegleria from all suspected or possible bodies of water in the Richmond area. Already over a hundred isolations of Naegleria have been grown out in culture and tested for pathogenicity in mice. We have not as yet encountered a strain comparable in pathogenicity to the strains of Naegleria isolated from fatal cases. As a result of comparison of culture response, morphology, electron microscope ultrastructure as well as pathogenicity we are inclined to agree with Carter (1970) and Singh (1970) who have given new species names to Naegleria strains isolated from fatal cases in Australia and Florida. A review of our progress in determining the environmental origin of pathogenic Naegleria will be given.

The RELATIONSHIP BETWEEN THE BACTERIA AND THE PLANT IN AMINO ACID FORMATION BY SOYBEAN NODULES. L.C. Olson Dept. of Biology, Christopher Newport Col. Newport News, Va. 23606

The isolated bacteroids of soybean nodules have previously been shown to fix N_2 to NH_4^{\dagger} , but the nitrogen translocated from the nodule is in the form of amino acids and amides. I report on the means present for forming amino acids from this NH_4^{\dagger} in the bacteria and plants grown separately and in the soybean nodules in which they are both present.

An active alanine dehydrogenase was present in $\begin{array}{c} \underline{Rhizobium\ japonicum\ grown\ either\ on\ an\ amino\ acid\ mixture \\ \underline{or\ on\ a\ medium\ using\ NH_{4}^{1}\ as\ the\ sole\ source\ of\ nitrogen.} \end{array}$

An active glutamate dehydrogenase, primarily linked to NADH, was present in non-nodulated soybean plants. In separations of nodule extracts using isopyenic sucrose density gradient centrifugation, much of the glutamate dehydrogenase activity was present in the mitochondrial fraction but neither glutamate nor alanine dehydrogenase was detectable in the bacteroid material.

PHOTODYNAMIC ACTION OF PROFLAVINE, METHYLENE BLUE AND CRYSTAL VIOLET ON DEOXYRIBONUCLEIC ACID. M. C. Noble* and S. G. Bradley, Med. Col. Va., Health Sciences Div., Va., Commonwealth Univ., Richmond, Virginia 23219

Photodynamic action of proflavine, methylene blue and crystal violet on two actinophages, <u>Streptomyces venezuelae</u> phage MSP8 and <u>Nocardia brasiliensis</u> phage MNP6, was found to be pH dependent. Added deoxyribonucleic acid (DNA) and ribonucleic acid effectively protected the actinophages from photoinactivation by these dyes. For proflavine, polyadenylate and polyinosinate afforded more protection against photosensitization than the other tested homopolymers. For methylene blue, the guanine derivatives were effective protecting agents. None of the added bases, nucleosides, nucleotides or homopolymers protected phage from photoinactivation by crystal violet. Proflavine increased the thermal stability isolated DNA in either 0.015 M NaCl-0.0015 M citrate or 0.01 M K_2HP0_4 ; the increased thermal stability was proportional to the adenine + thymine (AT) content of the DNA. The thermal stability of DNA in 0.01 M $\rm K_2HPO_4$ containing methylene blue decreased after exposure to light; the decreased thermal stability was proportional to the guanine + cytosine (GC) of the DNA. Crystal violet increased the thermal stability of DNA samples in 0.01 M KH,PO₄ after exposure to light; the increased thermal stability was proportional to the AT content of the DNA. Each of the dyes bind to DNA, proflavine to adenylate residues, methylene blue to guanylate residues and crystal violet to adenylate, thymidylate or both.

CARBOHYDRATE TRANSPORT BY HEAT-INJURED SALMONELLA TYPHIMURIUM. M. D. Pierson*. Dept. of Food Science and Technology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Salmonella typhimurium was grown in either Trypicase Soy Broth (TSB) or a citrate salts medium (CSM) and heatinjured at 48°C for 30 minutes. When injured TSB grown cells were placed in TSB, they recovered their tolerance to Levine's Eosin Methylene Blue Agar containing 2% salt within 3 hours. Injured TSB grown cells did not recover in CSM. Injured CSM grown cells recovered within 6 hours in either TSB or CSM. Warburg manometry showed that the rate of oxygen uptake and the total amount of oxygen consumed for various substrates was greater for injured cells than normal cells. The rate of endogenous oxygen uptake was depressed in injured cells. Radiorespirometry experiments revealed an 80% Embden-Myerhoff-Parnas and 20% hexosemonophosphate pathway participation in glucose metabolism for both normal and injured cells. However, the rate and total amount of $^{14}\mathrm{CO2}$ evolved from labeled glucose was always greater for injured cells. In the absence of an energy source, the rate of methyl- α -D-glucopyranoside (α-MG) accumulation was decreased following heat-injury. In the presence of an exogenous energy source, the rate of $\alpha\text{-MG}$ transport and level of $\alpha\text{-MG}$ accumulation was greater for injured cells than for normal cells.

SPORULATION PIGMENT FROM STREPTOMYCES VENEZUELAE. H. E. Scribner, III* and S. G. Bradley, Dept. of Microbiology, MCV-HSD, Va. Commonwealth Univ., Richmond, Virginia 23219

A pH indicator pigment has been isolated from the spores and aerial mycelia of Streptomyces venezuelae. The absorption maxima in the visible range are 430 nm at pH 3, and 520 nm at pH 12. Pigment is produced rapidly when the streptomycete is grown on tomato paste-oatmeal agar and glucose-salts agar, but only after a week on nutrient agar and peptone-yeast extract agar. Pigment production can be stimulated on peptone-yeast extract agar by the addition of glucose, citrate, or pyruvate. The production of pigment on solid media coincides with the development of aerial mycelia, and does not occur until aerial mycelia are produced. Preliminary data indicate that the pigment binds to deoxyribonucleic acid (DNA) and has antibiotic activity against Staphylococcus aureus. This pigment may be identical to the one isolated from abberrant DNA extracted from Streptomyces venezuelae spores.

MANGANESE CONTROLLED MORPHOGENESIS OF PENICILLIUM CLAVIGERUM AND PENICILLIUM CLAVIFORME. W.H. Tinnell, R. E. Benoit, and B. L. Jefferson, Biology Dept., Va. Polytechnic Institute, Blacksburg, Va. 24061

A defined medium was developed which contains maltose-proline-mineral salts. An organic nitrogen source is required for maximum cell yield of these fungi. A variety of amino acids will satisfy this requirement. Manganese is required for the production of coremia and we have demonstrated with ⁵⁴Mn that this "morphogenic trigger" is concentrated in the spores and coremia at a greater degree than the mycelium. Mn causes quantitative and qualitative changes in cell proteins. There was twice as much protein in the coremia then in the mycelium, and the re was twice as much protein in the mycelium when Mn was present in the medium. The optimum manganese concentration for the growth of P. clavigerum is 4.5 mg/1.

NUTRITION OF PHLYCTOCHYTRIUM SENIGLOBOSUM.

<u>Gilbert S. Trelawny</u>. Dept. of Biology, Madison
<u>Col.</u>, Harrisonburg, Va. 22801

Information concerning the nutrition of chytrids is slowly becoming available. Knowledge of this aspect of their physiology may lead to some insight as to their role in the biotic community, as well as determine if the current separation of species is correlated with differences in nutrition. Growth studies were carried out using a chemically defined mineral medium supplemented with individual carbohydrates and amino acids as sources of carbon and/or nitrogen. Comparison of growth was made on a dry weight basis. Although both types of substrates supported growth, the number of different substrates utilized by this fungus was quite limited. These results are discussed, together with a comparison of the nutrition of this genus with that of Rhizophydium.

THE UTILIZATION OF CARBON BY PHLYCTOCHYTRIUM SEMIGLOBOSUM. Robert D. Yoder, Dept. of Biology, Eastern Mennonite Coll., Harrisonburg, Va. 22801.

The utilization of carbon by Phlyctochytrium semiglobosum has been observed in this study using a medium containing glucose labeled with ${\rm C}^{14}$ as the sole carbon source.

The fate of this ${\rm C}^{14}$ was determined by counting the activity in the carbon dioxide, lipid and cell residue fractions.

This study indicates that of the $C^{1\,4}$ utilized, 23.1% was found in evolved CO2, 7.8% in the lipid fraction and 69.2% in the remaining cell residue.

Speculative interpretations are offered as to the various metabolic pathways available to the organism in its metabolism of glucose. Consideration is also given to the fixation of $\mathrm{C}^{14}\mathrm{O}_2$ and the effects this would have on the percentage of C^{14} found in the three fractions.

Section of Psychology

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

A MOTIVATIONAL ANALYSIS OF REM DEPRIVATION. I.B.Albert and G.A.Cicala*. Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508 and Dept. of Psychology, Univ. of Del., Newark, Del. 19711

Three experiments were performed in order to assess the appetitive effects and discriminative stimulus properties of rapid eye movement (REM) sleep deprivation in rats. The first experiment measured the latency to both behavioral non-REM and REM sleep produced by REM deprivation. The results indicated that REM deprivation specifically affects the latency to REM sleep while latency to non-REM sleep was unaffected.

In the second experiment, subjects were punished with electric shock for going into REM or non-REM sleep; and behavioral sleep latencies were recorded. The punishment of behavioral REM or non-REM sleep selectively lengthened the latency to REM sleep. In that the punishment of REM sleep did not produce longer latencies to REM than did punishment during non-REM sleep, it was concluded that the stimulus properties of REM sleep are not different from those of non-REM sleep and that the increased latencies produced by punishment were due to conditioned fear. The third experiment showed that increasing fear would increase REM latency.

It was generally concluded that REM deprivation directly affects appetitive measures of the REM motive; but REM sleep does not have stimulus characteristics which are discriminable from the other stages of sleep.

DISTRIBUTION OF RESPONSE LATENCIES IN CLASSICAL AND INSTRU-MENTAL AVERSIVE CONDITIONING. <u>Gary J. Bennett</u>*, and Michael W. Etkin, Va. Commonwealth Univ., Richmond, Va. 23220 Four pilot studies were conducted to determine the appli-

cability of response distributions as a dependent variable for the evaluation of drug effects on aversive conditioning. Previous research had indicated that response latency distributions for classical anticipatory and instrumental avoidance responses differed with anticipatory responses occuring just prior to US onset and negatively skewed while avoidance responses occured in the middle of the CS-US interval and were symmetrically distributed. Behaviorally moderate doseages of phenobarbital sodium, methamphetamine hydrochloride, chlordiazepoxide hydrochloride, and nicotinic acid were employed in a within subject design. Subjects were given 200 trials daily with alternating trials of classical defensive and instrumental avoidance contingencies; each of which was signalled by a discriminative CS which preceded the US by 5 sec.. Subjects were two female albino rats of inbred Wis-Analyses of variance on the mean response latencies and % CRs revealed that: a) phenobarbital decreased mean latencies for avoidance, but not for anticipatory responses (p .01), b) methamphetamine decreased mean latencies for anticipatory responses (p .05), but did not effect avoid ance responses, c) chlordiazepoxide had no discernible effects on either type of responding and d) nicotine increased the mean latencies for avoidance responses (p .05), and had no effect on anticipatory responses.

A SURVEY OF MNEMONIC TECHNIQUES USED BY COLLEGE STUDENTS IN FREE-RECALL LEARNING. Kenneth A. Blick and Carole J. Waite.* Dept. of Psychology, Univ. of Richmond, Va. 23173
In a survey of memory aids that college students would

employ in free-recall learning, Ss reported the following devices ordered by frequency of occurrence: first letter (34%), simple repetition (21%), clustering (16%), other (13%), personal experience (9%), and descriptive story No significant differences were found between men and women by category of memory aids reported. The incidence of the first-letter technique was not significantly different from the simple-repetition technique; however, the first-letter technique was reported significantly more often than the four other mnemonic systems. It was con-cluded that surveys of mnemonic techniques should be conducted in the otherwise well-researched areas of serial learning and paired-associate learning.

CRITICAL FLICKER FREQUENCY THRESHOLDS IN THE RAT AS DETER-MINED BY THE METHOD OF CONDITIONED SUPPRESSION. P. A. Buckner* and G. W. Kent. Dept. of Psychology, Bridgewater Col.

Bridgewater, Va. 22812

The purpose of this research was to develop methods and instrumentation for determining CFF thresholds with animals. The dependent variable was the number of licks of a water tube during a 10-second period. Responses were counted during a 10-second 'safe' period (S) immediately preceding the presentation of a flicker stimulus, and during the 10-second 'warning' period (W) concurrent with the flicker stimulus and immediately preceding any provided by foot stimulus and immediately preceeding an unavoidable foot shock. The suppression ratio was the ratio of the difference in response during the S and W periods to the S period. CFF $\,$ thresholds were computed by a modified method of constant stimuli in which a suppression ratio of .50 was used as the threshold criterion. 15 Long-Evans rats were given lick training until a steady baseline lick rate was obtained. Conditioning trials using a 4.4 Hz. flickering stimulus were given until a suppression ratio of .80 was obtained. Daily threshold sessions of 30 minutes were run. Three flicker rates were presented during a session: 100 Hz. on 85% of the trials as a steady light. 4.4 Hz. on 5% of the trials as the trials as a steady light, 4.4 Hz. on 5% of the trials as a suppression check, and threshold flicker rates on 10% of the trials. One luminance level was employed. The threshold values ranged from 29.9 to 31.3 Hz. compared to 85.4 Hz. for a human observer under the same stimulus conditions.

THE EFFECT OF STRESS, ACTH AND ASCORBIC ACID ON THE BLOOD PLASMA LEVEL OF CORTICOSTERONE AND CHOLESTEROL. G.Colmano and W.B. Gross, Dept. Vet. Sci., VPI&SU, Blacksburg, Va. 24061.

Stress expresses and subintends the action on a group (social stress) and on an individual, or the combination of diversified stressors represented by the single activity of an agent, be it physical (traumatic), chemical (parasitic-microbial-viral), or psychological (red light of alarm glowing without apparent physiological cause). Stress is qualitative-ly defined as a perturbation of homeostasis, and physiologically it is quantitatively characterized as a measurable entity, represented as the amount of blood plasma corticosterone which permits to extrapolate the amount of pituitary adrenocorticotropic hormone (ACTH) induced by the type and quantity of stress imposed. We found the level of stress to be proporof stress imposed. We found the level of stress to be proportional to the level of ACTH and corticosterone (Colmano, G., Va.J.Sci.,18:197,1967;Gross,W.B. and G.Colmano, Poultry Sci., 46:41,1967). We determined the level of cholesterol(following a modified Babson, A.L., et al, method,Clin.Chim.Acta.7:800, 1962) and corticosterone (by a modification of Guillemin,R., et al,fluorometric method,J.Lab.Clin.Med.53:830,1959) in the blood plasma of birds treated with ACTH and vitamin C(L-ascorbic acid), before and after infection by E. coli (108 viable cells) injected into the air sacs. The measured level of corticosterone and cholesterol, before and after achieving an infection with pathological lesions, shows constant trends correlating with the level of stress induced by the bacterial infection and it increases with the number and severity of pathological lesions. The antiinflammatory activity of ACTH and ascorbic acid are emphasized and correlated to the increase in stress and corticosterone and decrease in patholocrease in stress and corticosterone and decrease in pathological lesions. (Aided by NIH Grant No. AI-05418-BM).

ATTITUDES TOWARDS ABORTION: A REGIONAL COMPARISON STUDY OF PHYSICIANS. N.M.Cummings*, J.L.Ware*, and F.S.Murray. Dept. of Psychology, Randolph-Macon Woman's Col., Lynchburg, Va. 24504.

An attitude scale using the Thurstonian pro-

was constructed to measure attitudes towards abortion. Two samples of college under-graduates, one all female and one coed, were raduates, one all female and one coed, were asked to rate each item on an 11-point scale. The completed scale was sent to all physicians in Lynchburg, Va. and to 500 randomly selected physicians in New York City. Of the scales from Lynchburg, 66% (76 out of 113) and of the scales from New York City, 46% (229 out of 500) were returned within 30 days. Both groups showed a high degree of favorableness towards abortion. The median attitude for Lynchburg was 9.1 and for New York City, 9.3; no significant difference between the groups was observed. Further analysis tween the groups was observed. Further analysis were performed for differences between religious preference and fields of medical specialty.

PROBABILITY LEARNING AS A FUNCTION OF EVENT DURATION. Pattie Dougherty* and Elizabeth Byrd Mount*. Randolph-Macon Woman's Col., Lynchburg, Mount*. F Va. 24504

Twenty-eight female undergraduates participated in a two-choice learning task in which they predicted the occurrence of red or blue lights. There were 100 trials in each of three conditions. There were 100 trials in each of three conditions. Conditions were: (A)equal proportions of blue and red lights, the blue light being presented for 1 second and the red for 1.5 seconds, (B) unequal proportions of blue and red lights with blue 40% of the time for a duration of 1.5 seconds and red 60% for 1 second, and (C)with blue occurring 60% of the time for 2 seconds and red 40% for 3 seconds. The subjects probability matched on all conditions and no effects of stimulus duration were observed. It was concluded that unless the probability learning concluded that unless the probability learning experiment is designed so that subjects must attend to duration of the event, there will be no apparent duration effects. Suggestions were offered for modification of the design to account for the effects of duration.

IGNORING IRRELEVANT INFORMATION. <u>David G. Elnes</u>, Dept. of Psychology, Washington and Lee Univ., Lexington, Va. 24450. Psychology, Washington and Lee Univ., Lexington,

Six experiments clearly demonstrated that accurate memorization depended upon ignoring irrelevant information. In running paired-associate and free recall tasks, irrelevant information is segrecated in memory either by grouping items into relevant or irrelevant sets or by labelling individual members of a category as relevant or irrelevant and storing all items according to conceptual category membership. In either case, subjects attempt to use the relevant information and suppress the irrelevant material. (Supported by funds granted to Washington and Lee by the Sloan Foundation, a Robert E. Lee Research Grant, and NSF-Undergraduate Research Participation Grant GY 5798).

A BEHAVIOR ANALYSIS OF STUDENT ACTIVISM. J. C. Ficht, Dept. of Psychology, Norfolk State College, Norfolk, Va. 23504

Sixty-seven college students were administered a test instrument during a period of campus unrest. This test instrument included the Rosenberg Self-Esteem Scale, a Manifest Scale of Campus Activism (to distinguish between high involvement and low involvement in campus unrest), and a survey of student responsiveness to the mass media.

Results from test instrument did not indicate any difference between high involvement group and low involvement group on psycho-social variables as measured by the Rorschach and the Rosenberg Self-Esteem Scale. The high involvement group was found to have greater familiarity with the mass media's presentation of previous campus unrest, while the low involvement group reported decreased involvement after current news reports.

Study suggests that behaviors associated with campus unrest could be learned through modeling.

INTERORGANISM TRANSFER OF MATCH-TO-SAMPLE PERFORMANCE VIA BRAIN HOMOGENATE INJECTIONS. <u>J. A. Flora</u>* and G. W. Kent. Dept. of Psychology, Bridgewater Col. Bridgewater, Va. 22812

Twelve Long-Evans rats were given match-to-sample training on three levers and three stimuli with food reinforcement to a criterion of 85%. Two rats were randomly designated donor animals; one given training on a second and new match-to-sample task to criterion. The other was run the same number trials on the first task. Both animals were then sacrificed, the brains immediately removed, ground and cold centrifuged twice. The resulting homogenate was then administered to two groups of recipient rats. Six animals received the homogenate from the donor trained on the second task, five received the homogenate from the overtrained donon 5 microliters of homogenate were injected stereotaxically into the third ventrical bilaterally under sterile surgical conditions. Upon recovery all recipient animals were trained to criterion on the second match-to-sample task. The randomization test for two independent groups was used to evaluate trials to criterion data for the two groups. No statistically significant differences at the 0.01 level of confidence were observed.

FREE RECALL OF ITEMS PRESENTED AFTER MASSED AND DISTRIBUTED ITEMS. William I. Greener*, Dept. of Psychology, Washington and Lee Univ., Lexington, Va. 24450.

In order to better understand why distibuted practice (DP) on an item results in better retention than massed practice (MP), two experiments examined the free recall of words presented after words receiving MP (two adjacent repetitions during study) or after items receiving DP (two presentations separated by three or ten items). Each of the critical items in question was presented twice in the list: each presentation followed either a MP item or a DP item. More DF than MP items were free recalled, but the critical items presented after IP items were recalled more often than were critical items presented after distributed repetition. These results suggest that the second presentation of a MP item is markedly different from the second presentation of a DP item. (Supported by a Robert E. Lee Research Grant).

CYPECTS OF SCHSORY DEPRIVATION AND SCHSORY BOIRADDMENT ON CREATIVITY. Bernard C. Cricsby 11*. Vashington and Lee Univ., Lexington, Va. 24450

Assuming the validity of the Guilford, Draw-A-Person, and Torrance tests as measures of creative ability, an experiment was designed such that: (I) the nature of the relationship between intelligence and creativity could be explored, and; (II) the effects of sensory bombardment (SB) and sensory deprivation (SD) upon levels of creative performance could be examined. Initially, 30 male college students were tested for IQ (Otis) and creative ability. Three matched groups were then exposed to control, SD, or SD conditions, and subsequent test measures were obtained. Present data is incomplete. Dowever, measures of creative ability have been correlated with Ctis IQ scores, and preliminary evidence suggests that ST tend's to enhance creative performance, while SD tend's to decrease levels of creativity.

VISUAL MASKING IN MONKEYS. <u>Alastair V. Harris</u>* Dept. of Psychology. Radford Col. Radford, Va. 24141

Eight highly trained rhesus monkeys were tested in a backward masking paradigm using simple and complex stimuli. A forward masking paradigm was used with simple stimuli only. In all cases there was an increase in the discriminability of the stimuli with longer interstimulus intervals. Performance became asymptotic at approximately 70 msec. No difference between middle and old age subjects was observed when simple stimuli were used, but the older animals made significantly more errors with the complex stimuli.

The performance curves for backward and forward masking, using simple stimuli, were symmetrical, a finding which is in accord with the results of studies using human subjects using a Type A masking situation.

PUPILLARY RESPONSES DURING SHORT-TERM MEMORY TASKS: COCNITIVE PROCESSING, AROUSAL, OR BOTH? <u>David A. Johnson</u>, Dept. of Psychology, Sweet Briar College, Sweet Briar, Va. 24595

To assess the sensitivity of the pupil response to shifts in processing load, pupillograms of Experimental $\underline{S}s$ were obtained during a short-term memory (STM) task that included a signal to forget part of the material. A highly significant post-signal cycle of dilation-constriction was present in the pupillograms of the Experimental $\underline{S}s$ and absent in those of the Control $\underline{S}s$ for whom the signal had no meaning. The dilation phase of the cycle was interpreted as reflecting $\underline{S}s$ ' efforts to decode the signal and to differentiate the items in the list into subsets of items to be remembered or forgotten. The constriction phase seemed to reflect the reduction in processing load effected by the signal.

The results were seen to lend some support to cognitive interpretations of pupil change during tasks of this sort. However, such interpretations proved inadequate to account for some of the results, and certain non-processing explanations are offered.

It was concluded that pupil changes found during information processing tasks are frequently confounded with various motivational effects. (Aided by NSF grant no. GY - 6929)

FOLARIZED JUDGMENTS AS A FUNCTION OF GROUP DISCUSSION AND CUE COMBINATION. D. L. Johnson*
Dept. of Psychology, Radford Col., Radford, Va., 24141

Small groups and individuals rated hypothetical teachers on the basis of single attitude statements and on the basis of various combinations of these attitude statements.

For both single cue and multiple cue presentations, group ratings tended to be more polarized than individual ratings. Ratings of homogeneous sets of multiple cues tended to be more polarized than ratings of single cues for both groups and individuals.

AGE AND SOCIO-ECONOMIC BACKGROUND AS VARIABLES IN A MEDIATIONAL HYPOTHESIS OF DISCRIMINATION LEARNING. Katherine P. Jones*, Dept. of Psychology, Sweet Briar College, Sweet Briar, Va. 24595

The purpose of this study was to assess the performance of elementary school and kindergarten age children on reversal and non-reversal shift problems. The variables of age, socio-economic status, and reward contingency, each at two levels, were manipulated.

Forty-eight children served as subjects. The apparatus employed and the testing procedures used were modeled after Kendler. The relevant dimensions manipulated in the discrimination task were size and brightness.

The results were in support of the Kendlers' mediational theory in the case of the older children. The older children performed significantly better on reversal than on non-reversal shifts, but no significant differences were present between these same two conditions in the case of the younger children. An hypothesized interaction between age and social class was not tested due to limitations in the available subject population.

COMPLEX TONAL PATTERN DISCRIMINATION BY BLIND HUMAN SUBJECTS OF VISUAL-TO-AUDITORY TRANSFORMED STIMULI: AUDITORY BRAILLE. J. A. Leppington*, J. Layman and G. W. Kent. Dept. of Psychology. Bridgewater Col. Bridgewater, Va. 22812

The purpose of this study was to examine the acquisition of auditory discrimination of complex sequences of multitonal patterns representing verbal material. Inch high capital letters were translated into eight frequency auditory patterns when scanned by a hand-held optical probe containing eight ohotoconductors. Each photoconductor controlled a fixed frequency oscillator, turning it on and off as a segment of a letter was seen. Thus moving the scanner across a letter yielded a pattern of tones unique to that letter. Blind human subjects, students at the Va. School for the Deaf and Blind, Staunton, Va., served as subjects. The eight most frequent letters in the English language were used, singly and in simple words. Error data were recorded by trial for each scan rate and the course of acquisition of this task described.

CONSUMATORY BEHAVIOR AS A FUNCTION OF DEPRIVATION LEVEL OF THE RAT. P. M. Monti*. Dept. of Psychology, Col. of Wm. & Mary, Williamsburg, Va. 23185

The present study is an investigation of the relationship between strength of hunger drive and eating behavior. The experiment examines the usefulness of the Hullian concept of drive as opposed to an alternative position of stimulus generalization. The subjects, 36 female albino rats, were trained at 23 hrs. food deprivation and then tested at different deprivation intervals.

Significant findings, showing an increase in eating behavior up until training level and a subsequent decrease thereafter, clearly support an associative interpretation of stimulus generalization as opposed to a strict Drive position. Results are discussed in terms of the "associative" theories of Postman (1953b) and Estes (1958). Alternative mechanisms are suggested in terms of digestive and cyclical functions in the rat.

CONDITIONED SUPPRESSION IN MONKEYS PREVIOUSLY EXPOSED TO MOXIOUS STIMULI. A.C. Pratt. Dept. of
Biology, VPI & SU, Blacksburg, Va.
Super-imposing electric shock over previously

Super-imposing electric shock over previously conditioned fear was achieved using 110 db's of sound and a flickering strobe light. The group of experimental animals was h naive male Rhesus mankers. The control group was commanded.

or experimental animals was h naive male Rhesus monkeys. The control group was comparable.

All 8 animals were taught to bar press for reinforcement. Controls were then placed in neutral settings, ie. test chamber without bar and reinforcement. Experimental animals were exposed to noxious stimuli, also in the absence of the bar

The bar was returned after 8-14 days, and the noxious stimuli discontinued. Baseline bar press rates were established. A fixed amount of electrical shock was given to each animal. The result showed greater suppression of bar press rates in the experimental group, presumably because of the previously conditioned fear.

The control group also showed marked suppression, but not nearly as much as the experimental group.

STUDENT PERCEPTIONS OF THE COLLEGE ENVIRONMENT IN A DECADE OF CHANGE. Frederick B. Rowe, Dept. of Psychology, Randolph-Nacon Woman's Col., Lynchburg, Va. 24504

The <u>College and University Environment Scales</u> (CUES) is a questionnaire designed to measure the respondents (usually students) perceptions of the intellectual-social-cultural climate of their college.

Using data collected from seniors it was found that, during the years 1959-1969, there was a high degree of stability in the students' perceptions of the institutional environment in spite of such changes as the abolition of sororities and the end of de facto segregation.

Data collected in 1969 and 1971, however, indicate that

Lata collected in 1969 and 1971, however, indicate that student perceptions are undergoing marked change. This changing environment is, presumably, a joint function of changing motivational patterns in the current student population and a plethora of changes in institutional social regulations, curricula, examination procedures and other institutional practices.

THE DETECTABILITY OF VISUAL GAUSSIAN NOISE PATTERNS: MEAN AND STANDARD DEVIATION EFFECTS. Roberta Sadler* and Ricardo Dobson. Dept. of Psychology, Mary Washington Col., Fredericksburg, Va. 22401

Five observers (Os) made confidence ratings on a 4-category scale of the presence of a signal pattern next to a noise pattern. The signal and noise patterns were generated by the Gaussian random number generator of a computer. The patterns consisted of Xs and blanks; signal patterns contained a greater mean number of Xs than noise patterns. Two mean differences and 3 standard deviation differences were factorially combined so that each O was randomly presented the 6 combinations. Os were given 4 training sessions, and then exposed to 6 experimental sessions of 270 trials each approximately 4-day interression intervals.

at approximately 4-day intersession intervals. In general, the individual $\underline{0}$'s protocols yielded straight line z-coordinate ROC functions. Some $\underline{0}$ s failed to produce ROC functions when there was less overlap of signal and noise distributions resulting from low standard deviations for the signal distribution relative to the noise distribution; in this case, the $\underline{0}$ s did not make enough false alarms to determine a function. Mean difference manipulations produced a statistically significant effect for the obtained $d_{\underline{0}}$ s. While predicted slope manipulations did not produce systematic changes in obtained slope, the manipulations did change the obtained $d_{\underline{0}}$ in the predicted direction. The trend of the obtained $d_{\underline{0}}$ s was very adequately described in terms of slope and mean difference manipulations from the TSD model.

CONDITIONED SUPPRESSION IN TWO CLOSELY RELATED LINES OF DOMESTIC CHICKEN. A. H. Schulman, J. W. Cocke*, and A. A. Spevack*. Dept. of Psychology, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061.

State Univ., Blacksburg, Va. 24061.

The decrement in operant key-pecking produced by a stimulus previously associated with electric shock was assessed in hens selected for either high or low body weight. Subjects from the high-weight line exhibited significantly greater suppression ratios than did subjects from the low-weight line.

TRANSFER OF IMPRINTED BEHAVIOR VIA BRAIN HOMOGENATE INJECTIONS. A. H. Schulman, M. D. Spence*, and Christina B. Ferris*. Dept. of Psychology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The tendency to key-peck in order to view an imprinted

The tendency to key-peck in order to view an imprinted stimulus was transferred between turkeys by means of injections of forebrain homogenate. The transfer effect cannot be explained in terms of a general activity increase and is therefore assumed to be specific to the task.

THE DEVELOPMENT OF PASSIVE AVOIDANCE AND INHIBITION IN NEO-NATAL RATS. SAMUEL J. SHERMAN, VIRGINIA COMMONWEALTH U., RICHMOND, VIRGINIA. 23220

Neonatal rats were given repeated trials on a passive avoidance task from ages 8 days through 20 days. While there were no observed differences in latencies between these subjects and matched control subjects which only received one trial on either day 8, 10, 12, 14, 16, 18, or 20, there was a sudden increase in latencies on day 16 in both groups. The results are interpreted in terms of the development of a central inhibitory system.

ALCOHOL INTAKE IN LABORATORY ANIMALS. F. G. Slocumb*, Dept. of Psychology, Col. of Wm. and Mary, Williamsburg, Va. 23185

This study attempted to increase alcohol intake in rats by using a method of repeated exposures to increasing concentrations (Veale & Myers, 1969). In addition to the usual ethanol group, another group of rats was given bourbon, high in congeners, because recent reports have implicated congeners in alcohol addiction (Greenberg, 1970). In the twofluid three-bottle free-choice paradigm, the two experimental groups and a control group of female Sprague Dawley rats were tested for two consecutive six-week periods. Alcohol concentrations ranged from 1 to 30% (v/v). Experimental groups did not increase alcohol intake; also, post-tests at 1% and 10% concentrations yielded no significant differences in alcohol consumption between experimental and control animals. Since Veale and Myers (1969) found increased alcohol intake using male Long-Evans rats, these results may indicate important sex and strain effects in alcohol preference. new finding was a preference-aversion function for bourbon which is similar to that for ethanol. This suggests that high-congener alcohols also should be used in future studies.

ON THE DETERMINATION OF PICTORIAL IMAGE QUALITY. H. L. Snyder, Dept. of Industrial Engineering and Operations Research, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

From simple laboratory visual stimulus definition, through standard photographic imagery, to more sophisticated line-scanning systems such as television, there has been a need to define the visual quality of the picture. This paper will discuss some of the metrics used in image quality quantification in previous studies, and will present data from a recent series of experiments which indicate that pattern perception can be predicted largely by a unitary measure of image quality which combines contrast rendition, sharpness, and noise content. This measure, the Modulation Transfer Function Area, is shown to correlate highly with both information extraction performance and subjective scaled image quality.

PARTIAL DELAY OF REWARD IN THE DOUBLE RUNWAY. B. J. Still,*
B. N. Moore,*and P. G. Michaelson.* Dept. of Psychology,
Va. Polytechnic Inst., Blacksburg, Va. 24061

Following 72 trials of immediate reward in the first goalbox of a double alleyway, 90 hooded rats were shifted to partial delay of reward for an additional 48 trials. The partial delay of reward variable was combined with temporal delay of reward to form a 2 x 3 factorial design (two levels of temporal delay-10 sec. and 30 sec.; three levels of partial delay-25%, 50%, and 75%). Following the partial delay schedule, all Ss were shifted to 50% partial reinforcement in goalbox 1 for 36 trials. Results indicated that the 50% partial delay group ran significantly slower following delay of goalbox 1 reward than following no-delay (p4.05). No differences were observed in either the 25% group or the 75% group. The typical frustration effect occurred within all groups during the partial reinforcement phase. The data were discussed within a frustration-competing response interpretation.

FACTORS RELEVANT TO SELF-DISCLOSURE AMONG WOMEN. M. VanLandingham* and T.L. Pasternack. Psychology Dept., Randolph-Macon Woman's Col., Lynchburg, Va. 24504

Twenty female subjects (10 married women and 10 undergraduate students) designated as high disclosers and 20 female subjects (10 married women and 10 undergraduates) designated as low disclosers were selected from samples of 40 married women and 100 undergraduate students on the basis of scores on a self-disclosure questionnaire. Self-disclosure involves revealing some aspect of one's life to another person. Dyads who were to discuss eight topics of varying degrees of intimacy were formed originally with like-disclosing pairs. Next, dyads were formed with partners who differed in the degree of self-disclosure, and finally with like-disclosing pairs once again. All dyads consisted of a married woman and an undergraduate.

There was no significant difference between the self-disclosure behavior of married women and undergraduates. Lows disclosed significantly less to their partners than did Highs when dyads were formed with like-disclosing pairs. When Lows were paired with Highs, the Lows showed a significant increase in self-disclosure. The self-disclosure of the Lows in like-disclosing dyads was higher, though not significantly, following experiences with Highs than prior to such experience.

A STUDY OF SKIN TEMPERATURE CHANGE IN EMOTION: THE THERMAL DERMAL RESPONSE. W. L. Wampler* and G. W. Kent, Dept. of Psychology, Bridgewater Col. Bridgewater, Va. 22812

Initially conceived as a substitute for the GSR as an indicator of emotional response, the short term change in skin temperature, or thermal-dermal response, was found to have its own artifacts. Detection of this response was by means of a thermister in a bridge circuit, the output of which was fed into a low level differential amplifier and recorded by an ink-writing potentiometer which give 0.0004 Centigrade change per centimeter pen deflection. The signal to noise ratio was low at first and elicited emotional responses were difficult to detect from background temperature change. It was discovered that this background noise was the result of thermal output of the muscles beneath the transducer. The ear lobe was found to be best for studying elicited responses. Investigation of latency, duration, and magnitude of thermal-dermal response was studied as a function of locus of detection. Adequate stimuli employed were electric shock, sudden sounds, photographic material, printed and orally presented material. Both systematic increases and decreases in skin temperature were observed in elicited responses.

Section of Space Science and Technology

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

SOLUTION TECHNIQUES FOR LARGE BANDED MATRICES. F. W. Barton and R. T. Eppink. Dept. of Civil Engineering, Univ. of Va., Charlottesville, Va. 22901

A common characteristic of current procedures for the analysis of complex structures is the need for the solution of a large system of linear algebraic equations. Frequently, the particular algorithm used to achieve the desired solution determines the efficiency of the entire structural analysis procedure. The objective of this paper is to review some of the classical procedures currently used to solve such problems and to describe recently developed procedures, which efficiently treat banded or partially banded matrices.

Classical procedures, such as Gaussian elimination, are probably as good as any when the coefficient matrix is full. When the matrix is banded, certain of the classical procedures may be modified to take advantage of this banded character. A recent method, described as a wavefront process, minimizes computer storage requirements. The algorithm for this particular method is discussed and the procedure is compared with one of the techniques which process all elements within a prescribed bandwidth.

Often the sparse nature of a matrix can be significantly

Often the sparse nature of a matrix can be significantly reduced by appropriate numbering of the nodes of the structure. A method for renumbering nodes to reduce bandwidth is described. Solution efficiencies of the various node numbering schemes are compared for the wavefront and band processing methods.

ANALYSIS OF MULTIUNIVERSITY RESEARCH AND TECHNOLOGY CENTERS IN VIRGINIA. R. H. Bigelow, Chairman, Civil Engineering Group, Old Dominion Univ., Norfolk Va 23508

Norfolk, Va. 23508

Five research centers in the State of Virginia were studied for the purpose of establishing a partial basis for recommendations for a university consortium mechanism to provide an influence on environmental policy in the state. The analysis was made to identify factors responsible for growth and development and obstacles to the growth and development of the centers studied.

The primary source of information originated from interviews conducted with people directly involved in the research center activities and with people outside the research center having knowledge of its activities. These latter people were scientists, engineers or administrators practicing in the same discipline or a discipline closely related to that of the center or persons who directly or indirectly used the research product of the research center. The secondary source of information was the available documentation describing the centers.

This study was sponsored jointly by the National Science Foundation and The Commonwealth of Virginia.

CROSSWIND STUDIES ON ELEVATED STOL-PORTS. $\frac{\text{J.N. Blanton}}{\text{Va. }}$ and H.M. Parker, Univ. of Va., Charlottesville, $\frac{\text{Va. }}{\text{Va. }}$ 22901

A major problem associated with rooftop STOL-ports is that of crosswind control. It has been shown that crosswind velocity profiles can be altered drastically by the addition of different screen fence configurations to the lateral edges of the building rooftop. Several such fence configurations have been investigated on a two-dimensional building model in the low speed, 4'x5' wind-tunnel at the University of Va. It has been shown that for a given configuration and screen solidity, there are negligible variations in velocity profile due to differences in screen grid and wire size.

Large scale velocity fluctuations have been observed above the building rooftop for all configurations tested. The magnitude of these fluctuations were sometimes \pm 50% or more of the mean crosswind velocity. Tests performed on a three dimensional model at a higher Reynolds number in the Full Scale Tunnel at Langley Research Center showed no gross difference in the appearance of these fluctuations. A qualitative discussion explaining their existence is presented.

JET MIXING UNDER THE INFLUENCE OF A PRESSURE GRADIENT. D. F. Brink, School of Engineering, Old Dominion University, Norfolk, Virginia 23508

An analytical study of jet mixing under the influence of a streamwise pressure gradient is made for compressible, non-isoenergetic flows. A general form of the Illingworth-Stewartson transformation is utilized such that the analysis holds for both laminar and turbulent flows. The conservation equations are solved for each of the streams above and below the dividing streamline by using Meksyn's asymptotic method of integration for solving boundary layer problems. These two solutions are necessarily related to each other along the dividing streamline through the matching conditions.

In order that a comparison could be made with the results from previous studies, the problems of constant pressure mixing was also solved using Meksyn's method for laminar and turbulent flows. Excellent agreement was found when compared with the results from a numerical integration of the differential equation. The problem of laminar mixing between two parallel streams was investigated for the case of a constant pressure gradient. It was found that for nearly all cases investigated, the velocity and temperature profiles from the exact solution to the non-similar governing equations could be approximated by the locally similar solution.

COMMENTS ON A SOLUTION FOR SOIL-TIRE INTERACTION OF LANDING AIRCRAFT. R. Y. K. Cheng, Associate Professor, Civil Engineering Group, Old Dominion University, Norfolk, Va. 23508

The work is concentrated on developing a numerical solution for determining stress and velocity field due to large displacement of a soil material with particular application to aircraft landing on soil runways. The specific objective is to simulate on a digital computer the nonlinear behavior of a cohesive soil in the immediate zone of landing impact by the wheel. The environmental variable affecting the soil behavior are confining pressure, yield strength and strain-rate. Neglecting the elastic behavior, the governing equations, including all nonlinear terms are similar to those associated with time-dependent viscous flow of an imcompressible fluid. The study uses the Marker and Cell technique which represents the governing equations of the velocity field by a finite difference scheme. The pressure field is obtained by solving a finite difference Poisson's equation. The method requires a large memory high speed com-The resistance forces are calculated by integration, along the wheel boundary of the stresses which are defined by the velocity and pressure fields.

INFLUENCE OF VARIABLE PROPERTIES ON A STEP-HEATED SEMI-INFINITE SOLID. G. R. Crossman, * Assistant Professor of Engineering Technology, and R. L. Ash, Associate Professor of Engineering, Old Dominion University, Norfolk, Virginia, 23509

University, Norfolk, Virginia 23508

A perturbation solution is developed for the temperature distribution in a semi-infinite solid over a finite interval of time. The thermal conductivity is an arbitrary function of temperature, but the thermal diffusivity is restricted to a linear function of Kirchhoff's temperature variable. It is found that the perturbation parameter can take on larger values than expected and still apparently represent the temperature distribution. Special cases of constant thermal conductivity and thermal conductivity a linear function of temperature are presented and it is found that under some conditions thermal diffusivity variations dominate, whereas under other conditions the thermal diffusivity variation effects are negligibly small. A brief discussion is also given as to the possible usefulness of this solution in experimentally measuring temperature dependent thermophysical properties.

RESEARCH AT NASA-LANGLEY RESEARCH CENTER.

<u>Dr. John E. Duberq.</u> NASA-LRC, Hampton, Va. 23365 An overview of the research and engineering programs at Langley is presented. Research projects illustrative of the effort in aeronautics and manned and un-manned space flight are discussed. The aeronautics portion covers the speed range from V/STOL through hypersonic aircraft and the space portion covers the Viking and space shuttle programs. PROGRAMS OF RESEARCH IN ENGINEERING AT OLD DOMINION UNIVERSITY. G. L. Goglia, Thermal Engineering, Old Dominion University, Norfolk, Virginia 23508

The research projects currently in progress are presented. Particular emphasis is given the research efforts pertaining to the Viking Project, Space Shuttle and Aeronautics in general. An Aeronautics Graduate Research Participation Program is discussed.

INTERACTION OF GASES WITH ABLATIVE MATERIALS. II. WATER. R. H. Honeycutt* and J. P. Wightman, Chem. Dept., Va. Poly. Inst. and State Univ., Blacksburg, Va., 24061.

The results of adsorption studies of water by three filled elastomer composites, ESM-1004X, SLA-561 and SLA-561V are reported. The results of adsorption of water by the components of SLA-561 are reported also. Adsorption of water was measured as a function of pressure by a manometric technique in a constant volume system at 30°C for SLA-561; at 25°, 30° and 35°C for SLA-561V; at 30°C for ESM-1004X; and, at 30°C for the components of SLA-561. It was shown that water was predominantly adsorbed on the SLA-561 and SLA-561V and significantly less on the ESM-1004X samples. The order of adsorption of water was found to be phenolic spheres > ground cork > silica > fibers > glass spheres. Desorption of water from SLA-561V at 30° was studied also. There is no significant hysteresis in the adsorption-desorption process. (Supported under NASA Grant NGR 47-004-016).

RECENT ADVANCES IN REENTRY HEAT TRANSFER. G. R. Inger*, Dept. of Aerospace Engineering, Virginia Polytechnic Institute and State Univ., Blacksburg, Va. 24061.

Remarkably regular cross-hatched striation patterns have been observed on recovered reentry bodies and ablating supersonic wind tunnel models. Since the occurrance of these patterns can significantly influence the flight characteristics and aerodynamic heating of slender reentry vehicles, a basic theoretical and experimental study of their cause was undertaken. An analytical model is developed based on the theory that small sinusoidal disturbances in a turbulent supersonic boundary layer triggered by slight surface irregularities can resonantly interact with the corresponding disturbances within the surface ablation material. A wind tunnel study of boundary layer flow along a wavy wall was also carried out to verify this theory. The investigations have shown that a key non-dimensional parameter governs the formation of cross hatching: the ratio of the heat absorbed by ablation to the streamwise heat conduction within the surface material. This parameter not only correlates wind tunnel and flight test data but also suggests practical methods for suppressing the phenomenon.

EVALUATION OF THE USE OF STEADY-STATE DATA FOR THE DETERMINATION OF LINEAR AERODYNAMICS IN THE U.VA. COLD BALANCE WINDTUNNEL. J.R. Jancaitis and H.M. Parker, Dept. of Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

The U.Va. Cold Balance Windtunnel has the unique ability of observing the steady-state motion of aerodynamic models in a quasi-six degree of freedom state. This capability has opened the possibility of using the steady-state response of a model as a new information source in the calculation of stability derivatives.

An analytic and numerical study was undertaken to evaluate the efficiency and accuracy of obtaining aerodynamic coefficients from steady-state response observations. Computer programs have been developed and tested using generated data corrupted with normal random deviates. The results of these studies show that the steady-state mode of data reduction is much superior to conventional transient motion types in extraction of linear aerodynamics.

INTERACTION OF GASES WITH ABLATIVE MATERIALS. I. ARGON, CARBON DIOXIDE AND NITROGEN, <u>C. A. King</u>* and J. P. Wightman, Chem. Dept., Va. Poly. Inst. and State Univ., Blacksburg, Va., 24061.

The results of sorption studies of argon, carbon dioxide and nitrogen on two filled elastomer composites SLA-561 and SLA-561V are reported. Also, the results of sorption of the same gases on the components of SLA-561 are reported. The components of SLA-561 were phenolic spheres, silica spheres, ground cork, and a carbon fiber-glass fiber mixture. The composition of SLA-561V was similar to that above except that pure glass fibers were used in place of the carbon fiber-glass fiber mixture. The matrix in both cases was a silicone elastomer. Sorption was measured at 30°C as a function of pressure from 50 to 760 Torr by a manometric technique in a constant volume system. Studies at lower pressures $(2x10^{-3}$ to 1.5 Torr) were made in a constant volume system using calibrated thermocouple gauges. It was shown that the silica spheres did not take up any of the gases. Phenolic spheres took up only CO_2 , with the carbon fiber-glass fiber mixture and cork sorbing all three gases; in these two cases CO_2 was sorbed to the greatest extent and Ar only slightly greater than N_2 . The effect of sample geometry of SLA-561V on CO_2 sorption was determined. (Supported under NASA Grant NGR 47-004-016).

PROGRAMS OF RESEARCH IN THE DEPARTMENT OF AEROSPACE ENGINEER-ING AND ENGINEERING PHYSICS AT THE UNIVERSITY OF VIRGINIA.

A.R. Kuhlthau and J.E. Scott, Jr*, Dept. of Aerospace
Engineering and Engineering Physics, Univ., of Virginia,
Charlottesville, Virginia 22901
The areas of research now receiving particular emphasis

The areas of research now receiving particular emphasis in the department will be summarized and a few of the more important results from selected areas will be briefly reviewed. Particular emphasis will be placed on unique uses of magnetic suspension techniques, on a program involving a systems approach to problems of STOL air transportation and on atomic and molecular collision phenomena including problems in rarefied gas dynamics and gas-surface interactions.

DYNAMIC RESPONSE OF STRUCTURES TO MOVING MASSES

R. P. McNITT, R. RAGHAVAN* Department of Engineering Mechanics, VPI&SU, Blacksburg, Virginia 24061

Theoretical and numerical values describing the response of beams to moving masses are presented. The mass undergoes transverse as well as longitudinal oscillations with respect to the beam. The forces necessary to allow centrifugal accelerations due to mass motion along the beam's curvature is included and is shown to have small effects for very stiff beams. The theory is based on Fourier transforms and it is shown that many combinations of mass motions will cause resonance of the system.

LIQUID CRYSTALS FOR AIRCRAFT AND SPACECRAFT INSTRUMENT DISPLAY. J. B. Robertson* and R. K. Crouch. NASA - Langley Res. Ctr., Hampton, Va. 23365.

Two liquid crystal phenomena are being developed for possible spacecraft display application by RCA Laboratories for NASA Langley Res. Ctr. One phenomenon is the field-induced phase change in which a cholesteric phase liquid, which is milky or yellow irridescent, is changed to the nematic phase, which is clear, by application of an electric field. The second phenomenon is color switching in which a mixture of a pleochroic dye and a nematic liquid can change transmitted light from colored to white by application of a field. Advantages of liquid crystal displays are: low power requirement, flat package, and ambient front lighting. Problems to be overcome include narrow operating temperature ranges, long decay times, and short shelf life.

PRESENT AND PROJECTED DIRECTIONS FOR RESEARCH IN AEROSPACE ENGINEERING AT VPI & SU. J. A. Schetz*, Aerospace Engineering Dept., Virginia Polytechnic Institute and State University, Blackeburg Virginia 24061

Blacksburg, Virginia 24061
Current studies underway concerning Thermal Pollution, the Wing-Tip Vortex Problem, Air Traffic Control, Turbulent Noise, Jet Mixing at Supersonic Speeds, Liquid Jet Break-up, Space Shuttle Heat Transfer and Numerical Computation of Flow Fields will be described. Planned extensions of this work as well as new efforts in other fields such as automobile stability and control, new methods for rapid transit propulsion and coal dust settling in mines will be outlined. Guided tours of the research facilities will be available.

PARAMETER SELECTION FOR THE STABILITY OF NON-LINEAR STRUCTURAL SYSTEMS. W. D. Smith, Dept. of Aerospace Engineering, Va. Polytechnic Institute and State University, Blacksburg, Va. 24061

The positive definite character of functions for use in determining regions of stability for Liapunov application is examined. A positive definite function is defined in a manner analogous to quadratic forms. Two theorems are obtained which may be useful in determining regions of positive definiteness for the special case of a function which is quadratic in at least one of the variables.

THREE-DIMENSIONAL BOUNDARY-LAYER SEPARATION, D. P. Telionis

The boundary-layer equations behave singularly in the neighborhood of vanishing skin friction $(\partial U_{Oy}|_{q=\overline{0}}0)$. In a method probably influenced by the work of Goldstein, Landau has shown that the assumption of singularity implies $\partial U_{Oy}|_{q=\overline{0}}0$. It is presently shown in a similar way that the three-dimensional equations accept a Goldstein type singularity at similar equations accept a Goldstein type singularity at a saddle point of separation. Assuming that $\mathcal{N}, \partial u/\partial x$ and $\partial w/\partial x$ (see sketch) blow up, and using the continuity equation we deduce that u and w may be expanded in powers of $\sqrt{x_c x} = \sqrt{\frac{y_c}{x_c}}$ as $u(x_c, y_c) = u_c(y_c, z) + \beta_c \sqrt{\frac{y_c}{x_c}} + \beta_c \sqrt{\frac{y_c}{x_c}}$. (1) while u takes the form $u(x_c, y_c) = \beta_c \sqrt{\frac{y_c}{x_c}} = 0$ (1)

Substitution in the momentum equation and collection of terms of order $\chi^{-\frac{1}{2}}$, $\chi^{\frac{1}{2}}$, gives a set of differential equations that may be solved for the functions

equations that may be solved for the functions P_2 , P_3 , ...
under certain conditions. The dominant terms give $u=u_o+A\frac{\partial u_o}{\partial y}\sqrt{\chi}+O(\chi)$ (3) $w=w_o+A\frac{\partial w_o}{\partial y}\sqrt{\chi}+O(\chi)$ (4)

Equations (3) and (4) evaluated at y=0 yield $\frac{\partial u_o}{\partial y}|_{y=0}=\frac{\partial w_o}{\partial y}|_{y=0}=0$ (5)

Relationships (5) express the vanishing of both components of the skin friction vector which is indeed the property of the skin friction vector which is indeed the property of a saddle point for the family of skin friction lines.

MONTE CARLO APPLICATIONS TO ACOUSTICAL FIELD SOLUTIONS. B.D. Thanedar* and J.K. Haviland. Dept. of Aerospace Engineering, Univ. of Va., Charlottesville, Va. 22901

The Monte Carlo technique is proposed for the determination of the pressure-time history at chosen points in a partial enclosure, the central idea of this technique being the tracing of rays. The problem is considered one of Random Walk with finite Markov chain simulation. A statistical model is formulated and an algorithm for pressure is created. the confirmity of which is examined critically by different approaches and is shown to give the known results. Most of the theoretical work presented in this paper is directly applicable to the case of a homogeneous medium, but the scope of future development to make the present method more generally applicable is also indicated. The concepts that are developed are applied to the determination of the transient field due to a sound source in a homogeneous medium enclosed by perfect reflecting walls, and the results are compared with those presented by Mintzer based on the Laplace Transform approach. In contrast with the latter, the Monte Carlo approach is in no way restricted to the case of perfect reflecting walls, in fact, variations of the boundary conditions at the walls can be taken care of almost trivially. The Monte Carlo method is felt to be a valuable tool when boundary conditions are very complex. (Aided by NASA Grant No. NGR-47-005-0085)

TURBULENT BOUNDARY LAYER ANALYSIS. <u>E. R. Van Driest*</u>, Dept. of Aerospace Engineering, Va. Polytechnic Inst., Blacksburg, Va. 24061

An attempt is made to clarify the basic notions leading to the complete velocity profile of a fully developed turbulent boundary layer in a constant pressure field. first shown that the assumptions that the Prandtl mixing length is proportional to the distance from the wall requires that the eddy viscosity be constant along the edge of the laminar sublayer, which incidentally is also a streamline Thus, it is further concluded that the semi-logarithmic law for velocity profile is at least a tangent condition for commencement of the turbulent profile. It is next considerto the size of the boundary layer and that these are represented by a correlation function having a gaussian distribution. Integration of this distribution then yields an error function variation for mixing length which appears to fit measured data quite well. Resulting velocity profiles accordingly also agree with experimental data including the semi-logarithmic and very-near-wall portions. (Supported by AFOSR Grant 71-2039).

*
$$\frac{\lambda}{\delta} = 0.09[1-\exp(-\frac{y^{+}}{26})] \operatorname{erf}(\frac{4y^{+}}{\delta^{+}})$$

AN ELECTRONICALLY DESPUN CIRCULAR ARRAY FOR THE SMALL PLANETARY EXPLORER. Roger Yaminy*, Radiation Systems, Inc., McLean, Va. 22101

The subject of this paper is a circular array capable of 360° azimuth scanning. The array is fed by a matrix, which is in turn fed by continuously variable varactor phase shifters and thus the array has in theory infinitely many beam positions, and can be rapidly scanned, limited only by the speed of the solid state driving circuitry. The array is also capable of providing a low gain omnidirectional azimuth beam as an alternate mode of operation.

The array is designed for high gain, lightweight and to be able to withstand space environments. Array elements are printed circuit dipoles positioned over corner reflectors. The design frequency range is from 2.1 GHz to 2.3 GHz. The highest measured gain is 16 db. Gain fluctuation is \pm 1.25 db about the mean, when the array is electronically scanned with the existing driver circuit.

The performance of the array is discussed. In addition, since this array has a foam dielectric matrix, the matrix' construction and performance are also discussed. The paper concludes by presenting some of the advantages and limitations of such an array, directions for improvement, and also modifications to realize the full versatility of the array.

Section of Statistics

Forty-ninth Annual Meeting of The Virginia Academy of Science May 12–14, 1971, Blacksburg, Virginia

CONFIDENCE LIMITS FOR A PARAMETER WITH SOME CHARACTERISTIC RESTRICTIONS. R. L. Andrews and J. C. Arnold, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Some parameters have a restricted range due to the nature of the parameter, such as distance must be non-negative. Confidence limits for a parameter of this type are found for an observation that is distributed normally about the parameter. Optimum limits of fixed length about a point estimate are derived for the cases of the conditional variance known and unknown.

A SMOOTH EMPIRICAL BAYES ESTIMATION TECHNIQUE. G. K. Bennett. Dept. of Industrial Engrg. and Operations Research, Va. Polytechnic Inst. and State Univ., Blacksburg. Va. 24061

Polytechnic Inst. and State Univ., Blacksburg, Va. 24061
A continuously smooth empirical Bayes estimator is presented and used to obtain estimates for the parameters of a known distribution. The estimator is obtained by means of a continuous approximation to the prior density function. Results from Monte Carlo studies are reported illustrating that these estimators have smaller mean-squared errors than some commonly used classical estimators.

A CONSTRAINED OPTIMIZATION METHODOLOGY FOR PROCESS DEVELOPMENT, \underline{W} . E. Biles*, Dept. of Industrial Engineering and Operations Research, Va. Polytechnic Inst. and State Univ., Blacksburg, Va., 24061.

The development of manufacturing processes for composite materials is treated as a stagewise operation which combines experimentation, response surface model development, and constrained mathematical optimization. Initially, a designed experiment is conducted over the widest possible factor space, considering any independent variables believed to significantly influence product responses. The most efficient designs are possible when the set of independent variables is partitioned into subsets of composition variables and process variables. Low order response surface models are fitted to the experimental data and tested for validity. A constrained optimization problem is formulated with an aim to optimizing a primary product response, subject to constraints arising from processing conditions and from specifications on secondary product responses. The optimization problem is solved using a constrained multivariable search procedure. This cycle is followed by another cycle in a reduced factor space about the indicated optimum. These operations are repeated in each block of a multiple block development program. The optimum indicated by the last block permitted by time and budget restrictions is implemented as a manufacturing process.

THE ESTIMATION OF STABILITY AND CONTROL PARAMETERS FROM FLIGHT TEST DATA. Roland L. Bowles*, NASA Langley Research Center, Hampton, Va. 23365

The structure of a maximum likelihood estimator suitable

The structure of a maximum likelihood estimator suitable for extracting stability and control parameters from flight test data is presented. Results obtained using this estimator are compared with manufacturer's data for the F^4-J aircraft.

ON THE ASYMPTOTIC INDEPENDENCE OF THE MAXIMA IN A ON THE ASYMPTOTIC INDEPENDENCE OF THE MAXIMA IN A BIVARIATE NORMAL POPULATION. J. W. Campbell* and C. P. Tsokos, NASA Langley Res. Ctr., Hampton, Va. 23365, and Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Let {(X_i, Y_i), i=1,...,n} be a sample of independent observations drawn from a bivariate population. The authors have developed a general

pendent observations drawn from a bivariate population. The authors have developed a general method for obtaining the limiting distribution, as $n o \infty$, of the maxima $\xi_n = \max\{X_1, \dots, X_n\}$ and $\eta_n = \max\{Y_1, \dots, Y_n\}$ drawn from distributions which have a canonical expansion. After a brief description of these results, the method will be illustrated by applying it to the standardized bivariate normal applying it to the standardized bivariate normal distribution whose canonical expansion is the well-known Mehler identity. The result is that the asymptotic joint distribution of (ξ_n, η_n) from a bivariate normal population with $|\rho|<1$ is the product of the univariate asymptotic distributions of ξ_n and η_n . This agrees with the previously known fact that the maxima in bivariate normal samples become

uncorrelated, i.e. independent, as the sample size increases without bound.

The authors are currently in the process of applying their method to other bivariate distributions whose canonical expansions are known.

THE EFFECT OF GROUPING ON VARIANCE AND BIAS OF THE MAXIMUM LIKELIHOOD ESTIMATOR OF THE POISSON PARAMETER: SOME MONTE CARLO RESULTS. W. H. Carter, Jr. and R. H. Myers, Department of Biometry, Medical College of Virginia, Richmond, Virginia 23219

Hartley developed a procedure for solving the likelihood equations resulting from incomplete samples which employed the method of successive approximations. When the Poisson distribution is partitioned into connected groups, it has been shown that Hartley's method converges to the unique solution of the likelihood equation regardless of the choice of starting value. In the present paper, the impact of this type of grouping on the asymptotic variance and bias of the estimator is studied. In addition, graphical illustrations of the results of a Monte Carlo study are given which indicate how the bias and per cent gain in variance of the estimator is affected by "group size" and magnitude of the parameter of the parent distribution.

THE USE OF STEEPEST ASCENT IN RESPONSE SURFACE EXPERIMENTS. G. W. Cobb * . Dept. of Biometry, Med. Col. of Va., Richmond, Va. 23219

When a response surface experimenter takes single observations along an estimated path of steepest ascent, he uses a stopping rule to decide after each observation whether or not to take another observation. The current stopping rule (which instructs the experimenter to continue taking single observations until the difference between successive observations is negative) does not make adequate provision for the random error which attaches to the observations. Rewriting the stopping rule as a test of an hypothesis on the slope of the response leads to alternative stopping rules which use other test statistics; a squared error loss function is used to select the optimum test statistic and optimum test level for various response surfaces.

A MODEL FOR PREDICTING THE INCIDENCE OF ACUTE HUMORAL RE-JECTION IN RECIPIENTS OF MULTIPLE KIDNEY TRANSPLANTS.

G. W. Cobb*, and J. C. Pierce*. Depts. of Biometry and Surgery, Med. Col. of Va., Richmond, Va. 23219

The incidence of acute humoral (hyperacute) rejection in 153 renal allotransplants was 3.3% while in 31 second, third, and fourth transplants it was 35%. In order to test whether or not immunization by previous transplants to HL-A antigens distributed at two sub-loci could account for this striking increase, a model was postulated which allowed an expected frequency of rejection to be computed for donor recipient combinations of various relatedness, races, and numbers of transplants. The predicted 12.2 cases of acute humoral rejection agreed well with the observed 11 cases, with close

agreement for several subgroups.

The model illustrates the extension and application of several elementary laws of probability for unions and intersections of elementary events.

SOME PHILOSOPHICAL OVERTONES OF STATISTICAL INFERENCE. Whitfield Cobb. Dept. of Statistics, Va. Polytechnio Inst. and State Univ., Blacksburg, Va. 24061

To contrast with the phrase, 'philosophical implications,' which connotes the logical, epistemological, or metaphysical presuppositions of an endeavor, 'philosophical overtones' is chosen to label principles and practices capable of wider label principles and practices capable of wider application than the technical implementation in which they originated. They are philosophical in the sense that they pertain to the love of wisdom.

A statistical test combines without confusing

a model, a null hypothesis, and the experimental value of a test statistic. In other areas also, we should recognize and distinguish assumptions not now on trial, assumptions we are prepared to disoard in the face of new facts, and empirical evidence relevant to these assumptions. That the same evidence oan lead to either rejection or non-rejection, depending upon which level of significance has been chosen, suggests that the persons with whom we disagree are not necessarily blind to what we see so clearly but may have subconsoiously chosen to use risks of error different from ours.

Ten additional philosophical overtones are drawn from estimation or testing. A final example applies the regression fallacy to ourrent history. A STOCHASTIC MODEL FOR AN EVOLUTIONARY PROCESS. A. I. Dale* and K. Hinkelmann. Dept. of Statistics Va. Polytechnic Inst. and State Univ., Blacksburg,

Va. 24061
Random selection of gametes and random fluctuations in systematic evolutionary pressures are well known to be of importance in population genetics. The process of change in gene frequency satisfies the Kolmogorov forward equation

$$\frac{\partial}{\partial t} \ \phi \ = \ 1/2 \frac{\partial^2}{\partial x^2} \{ V_{\delta_X} \phi \} \ - \ \frac{\partial}{\partial x} \{ M_{\delta_X} \phi \} \ ,$$

 $\rm M_{\delta_X}$ and $\rm V_{\delta_X}$ representing respectively the mean and variance of change in gene frequency per generation. Changes which are due to neither mutation nor migration are said to be due to selection. Consideration follows: ation of changes due to the random selective advantage of one allele over another leads to random versions of the above equation. Here a simple version is solved by various means, and certain statistical measures are calculated.

NOTES ON THE HISTORY OF THE METHOD OF LEAST SQUARES. C. Eisenhart*. National Bureau of Standards, Washington, D.C. 20234
Antecedents and alternatives to Least Squares. The three distinctly different formulations, of Legendre (1805), Gauss (1809), and Gauss (1821) that differ not only in their aims and initial assumptions but also in the meanings that they attach to the numbers that all three yield as a common answer to a particular problem. Hazards common answer to a particular problem. Hazards of uncritical use of least squares computer programs.

A NON-PARAMETRIC EMPIRICAL BAYES ESTIMATOR

 $\frac{W.~D.~Ergle}{V.P.I.}$ and S.U., and R. G. Krutchkoff, Department of Statistics, tics, V.P.I. and S.U., Salem, Virginia 24153

A non-parametric empirical Bayes estimator which requires only vectors of independent, identically distributed random variables of length greater than or equal to two and the existence of a consistent sequence of estimators for the parameter to be estimated. Under these conditions, the estimator is asymptotically optimal relative to the Bayes risk if the loss function is squared error.

Monte Carlo results indicate that the estimator possesses excellent small sample properties. The performance of the estimator when used to estimate a mean, median, variance. standard deviation and percentile indicate the improvement over other methods of estimation was significant regardless of the nature of the parameter to be estimated.

SIMPLE LINEAR REGRESSION WITH GROUPING IN THE DEPENDENT VARIABLE. R. E. Flora, J. V. Bowen, Jr., G. W. Cobb, W. H. Carter, Jr., Dept. of Biometry, Med. Col. of Va., Richmond, Va. 23219

A simple linear regression model is assumed in which observations on the dependent variable are grouped into mutually exclusive intervals. A general expression is mutually exclusive intervals. A general expression is given for the likelihood equation. Under the usual assumptions of homoscedasticity and normality, an iterative procedure is given for obtaining maximum likelihood estimates of the parameters. A numerical example is presented to illustrate the technique.

FORECASTING MODELS FROM NON-STATIONARY STOCHASTIC REALIZATIONS. F. C. Fuller, Jr., and C. P. Tsokos. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The techniques of time series analysis must be modified when used to obtain forecasting models from data which arises from a mechanism which generate non-stationary stochastic realizations.
In this paper we discuss how to identify the data as stationary or non-stationary, we present a technique whereby the non-stationary data can be filtered allowing it to be treated as stationary, and once, we have fitted a model, a "backward filter" to forecast values of the non-stationary data. These techniques are then applied in the analysis of the closing values of the New York Times Stock Index for the year 1967.

LIFE TESTING AND RELIABILITY ESTIMATION FOR THE ONE-PARAMETER EXTREME VALUE DISTRIBUTION. J. H. Godbold, Jr.*, and C. P. Tsokos, Department of Health, Education, and Welfare, and Department of Statistics, VPI&SU.

The aim of this paper is to consider the modified extreme value probability density model of the form

 $f(x;\theta) = \frac{1}{\theta} \exp\{-\frac{1}{\theta}[e^{x}-1]+x\}, x > 0, \theta > 0$ to characterize the times to failure of a given component and obtain minimum variance unbiased estimates of the parameter θ and the reliability function R(t), given by

 $R(t) = Pr[T \ge t] = exp[-\frac{1}{\theta} \{exp(t) - 1\}].$

A computer simulation is employed to illustrate the usefulness of the estimates. Various areas where the extreme value probability distribution is applicable is also discussed.

CANONICAL EXPANSION OF THE BIVARIATE BINOMIAL DISTRIBUTION WITH UNEQUAL MARGINAL INDICES. M. A. Hamdan*. Dept. of Statistics, Virginia Polytechnic Institute and State Univ., Blacksburg, Va., 24061. Aitken and Gonin derived the bivariate binomial

distribution by considering a sample of size n classified in the form of a 2x2 table. The resulting bivariate binomial was expressed in the form of a finite series bilinear in Krawtchouk's polynomials in the marginal variables. The marginal distributions were binomial with the same index distributions were binomial with the same index n(the sample size for the 2x2 table) but with different probabilities of success p₁ and p₂. The present paper gives a derivation of the bivariate binomial distribution with different marginal indices n₁ and n₂ and the same probability of success p for both marginals. The derivation is based on the additive property of independent binomial random variables with the same p. The bivariate factorial moment generating function is bivariate factorial moment generating function is derived, and hence the bivariate probability density function is expressed in canonical form. The correlation coefficient is derived and the regression lines are found to be linear. The results are applied to the problem of double sampling in quality control.

STATISTICAL TREATMENT OF NON-NORMALLY DISTRIBUTED STRESS CORROSION DATA. J. H. Harshbarger*, A. I. Kemppinen, and B. W. Strum. Reynolds Metals Company, Richmond, Va. 23218

The maximum-likelihood method of estimating the parameters of a Weibull distribution of failure

times is described.

A procedure for detecting differences between samples, based on testing differences in the Weibull distribution parameters, rather than means, is discussed and an example is given.

The point estimate - the probability of failing after a specified time - is calculated from the Weibull distribution.

The lower confidence bound of the estimate of reliability related to a point in time is shown,

accompanied by an example.

A procedure for writing specifications on stress

corrosion testing, recognizing the underlying distribution of failure times, is recommended.

All of the above methods are presented as procedures for analyzing data from non-normal distributions. As some of these procedures require the

use of a computer, a computer program to perform these analyses is described.

The purpose of this paper is to popularize by description and example an application of recent research to the problem of testing stress corrosion data.

STATISTICAL CONSULTING: A GRADUATE COURSE.

STATISTICAL CONSULTING: A GRADUATE COURSE. K. Hinkelmann. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061
In the last few years there has been some discussion about the teaching of statistical consultancy at universities. Various methods of achieving this have been proposed and tried. Among these approaches, Cox (Biometrics, 1968) has recommended a systematized, course-wise training for consultants. This paper discusses the content of such a course more specifically, how it can be implemented, and how it can benefit how it can be implemented, and how it can benefit the students.

A BIVARIATE STATISTICAL ECOLOGY MODEL. S. W. Hinkley* and C. P. Tsokos. Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

This paper examines a simple stochastic model describing a birth-and-death process for two animal species whose life processes are somehow related in an ecosystem. The exact nature of the interrelationships is unspecified and this generality in the model allows simultaneous considera-

ality in the model allows simultaneous consideration of both the well known predator-prey system
and the system of mutual competition.

The bivariate frequency function for the population sizes is derived from the differential
equations of the model and the problem of parameter estimation is discussed briefly. Some problems are suggested for further work, particularly lems are suggested for further work, particularly with regard to the functional forms of the infinitesimal birth and death rates.

EMPIRICAL TESTS OF THE QUANTITY THEORY OF MONEY IN THE U.S. 1900-1930. T. M. Humphrey.* Fed. Res. Bank of Richmond, Richmond, Va. 23213.

Testing of the quantity theory played an important role in the early development of some statistical techniques and their application to economic data. For example, U.S. economists' initial use of correlation and distributed lag analyses were in tests of the quantity theory. This paper reviews quantity theory research with special reference to new statistical techniques employed (correlation analysis, trend and cycle analysis, distributed lag analysis, price index construction) and evaluates the contribution of em-

pirical work to the advance of the quantity theory. One important finding is that research in the 1920's, allegedly establishing the cyclical invariability of the velocity-transactions (V/T) ratio, may have contributed to the propagation of the crude version of the quantity theory much criticized by Keynesian economists in the 1930's and 1940's.

The paper concludes that testing of the theory contributed more to statistical than to monetary analysis during 1900-1930 (advances in statistical techniques in that period were matched by neglect of monetary theory and by failure to devise more subtle empirical models for testing purposes) but that it was beneficial to monetary theory in the long run. The recent revival of the quantity theory owes much to the empirical tradition of the 1900-1930 period.

MINIMUM VARIANCE UNBIASED ESTIMATE OF RELIABILITY USING THE TRUNCATED WEIBULL FAILURE MODEL. T. W. Jones* and C. P. Tsokos. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24961

The aim of this paper is to obtain the minimum variance unbiased estimate (MVUE) of the reliability function and of the scale parameter for the failure model which has been described by the truncated Weibull probability density function given by

f(x;
$$\theta$$
, ρ) =
$$\begin{cases} \frac{\rho}{\theta} x^{\rho-1} \exp\left[-\frac{(x^{\rho} - c^{\rho})}{\theta}\right], (0 < c \le x, 0 < \theta, \rho) \\ 0, \text{ elsewhere} \end{cases}$$

where θ is the scale parameter, ρ is the shape parameter, and c is the point of truncation. achieving our objective, we utilize the Rao-Blackwell and Lehmann-Scheffe theorems.

The MVUE of the scale parameter θ is given by

$$r\hat{\theta} = \sum_{i=1}^{r} (x_i^{\rho} - c^{\rho}) + (n-r) (x_r^{\rho} - c^{\rho}).$$

$$\begin{split} r\hat{\theta} &= \sum\limits_{i=1}^{r} (x_i^{\rho} - c^{\rho}) + (n-r) \left(x_r^{\rho} - c^{\rho}\right). \\ \text{The MVUE of the reliability function } R(t) \text{ where} \\ R(t) &= \exp\left[-\frac{(t^{\rho} - c^{\rho})}{(t^{\rho} - c^{\rho})}\right] \text{ is given by} \\ R^*(t) &= \left[1 - \frac{(t^{\rho} - c^{\rho})}{r\hat{\theta} - (n-r) \left(x_r^{\rho} - c^{\rho}\right) + (n-r+1) \left(v_{r-1}^{\rho} - c^{\rho}\right)}\right]^{r-1}. \end{split}$$

A COMPARISON OF VARIOUS ESTIMATORS OF THE MEAN A COMPARISON OF VARIOUS ESTIMATORS OF THE MEAN WHEN THE PRIOR P.D.F. IS A LINEAR COMBINATION OF PDF'S. B. F. Klugh, Jr.* and J. C. Arnold. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061 The problem of estimating the mean θ for a uniparameter distribution is considered. The Bayes prior density $h(\theta)$ is assumed to be a linear combination of p.d.f.'s; of the form

bination of p.d.f.'s; of the form $h(\theta) = ph_1(\theta) + (1-p)h_2(\theta)$ where $h_1(\theta)$ and $h_2(\theta)$ are p.d.f.'s for the unknown mean θ and p is a probability. In view of the form of $h(\theta)$, five different estimators are considered, each dependent upon the extent of prior information. They are: (i) A Bayes estimator, $\theta(y)$, whose prior is a linear combination of p.d.f.'s, (ii) A preliminary test estimator $\theta(y)$, which decides between the Bayes estimators derived from the p.d.f.'s in (i), (iii) A psendo-Bayes estimator, $\theta(y)$, based on an illegitimate mixed prior density function, (iv) A Bayes estimator, $\theta(y)$, whose prior density is a linear combination of a diffuse and a nondiffuse component, (v) A preliminary test estimator, $\theta(y)$, which decides between a Bayes estimator and a classical estimator. An example when the conditional p.d.f. is normal is discussed.

MELLIN TRANSFORMS AND THE DISTRIBUTION OF THE SUM OF TWO LOGNORMAL VARIATES. G. Lowrimore* and C. P. Tsokos, Department of Health, Education and

Welfare, and Department of Statistics, VPI&SU.
Naus [Journal of the American Statistical Association 64 (1969), 655-659] derived a series expansion for the moment generating function of the logarithm of the sum of two random variables whose logarithms are independent normal variates with equal variances and zero means. The aim of this paper is to generalize the results of Naus by obtaining the probability density function and the kth moment of the above sum. The main mathematical tool used is Mellin Transforms. The distribution of the logarithm of the sum of two lognormal variates is of importance in communication engineering.

A STOCHASTIC MODEL FOR VIRAL DEVITALIZATION. J. Massey* and R. G. Krutchkoff. Dept. of Statistics Va. Polytechnic Inst. and State Univ., Blacksburg,

Va. 24061 Viruses often exhibit unusual behavior when exposed to destructive chemical or physical agents. exposed to destructive chemical or physical agents. A mathematical model based on the assumption of aggregation was developed by Clark (1968) to explain the aberrations of the survival curves of these viruses. The virions are assumed to exist as singles and aggregates up to any size that seem reasonable for a particular virus.

A stochastic model is now developed which gives the probability distribution for each aggregate.

the probability distribution for each aggregate size after a given exposure time t. The mean and variance are also presented for each clump size. (Supported by EPA training grant WP-166.)

Lp-STABILITY OF SOME STOCHASTIC CONTROL SYSTEMS, D. B. McCallum* and C. P. Tsokos, Dept. of Statistics, VPI&SU, Blacksburg, Va., 24061.

The aim of this paper is to study the stochastic control system given by

 $\dot{\mathbf{x}}(\dot{\mathbf{t}},\omega) = \mathbf{A}(\omega)\mathbf{x}(\dot{\mathbf{t}},\omega) + \mathbf{b}(\omega)\phi(\sigma(\mathbf{t},\omega))$

 $x(t,\omega) = A(\omega)x(t,\omega) + b(\omega)\phi(\sigma(t,\omega))$ $\sigma(t,\omega) = f(t,\omega) + \int_0^t c^T(t-\tau,\omega)x(\tau,\omega)d\tau,$ where $\omega \epsilon \Omega$, the supporting set of the probability measure space $(\Omega, \mathbf{d}, \mathbf{P})$, $x(t,\omega)$ is an $n \times 1$ random vector, $A(\omega)$ is an $n \times n$ random matrix of measurable functions, $b(\omega)$ and $c(t,\omega)$ are $n \times 1$ random vectors of measurable functions, and $\phi(\sigma(t,\omega))$, $\sigma(t,\omega)$, and $f(t,\omega)$ are scalars. Our main concern is obtaining conditions under which the above system is taining conditions under which the above system is $\rm L_{\rm p}$ stable with respect to bounded perturbations. That is, the trivial solution to the above system That is, the trivial solution to the above system is L_D stable with respect to bounded perturbations if for any $\epsilon>0$ and $t_0\epsilon [0,\infty)$, there exists a $\delta (\epsilon,t_0)>0$ such that for any $\mathbf{x}_0(\omega)\epsilon L_D(\Omega,\mathbf{Q},\mathbf{P})\cap L_\infty(\Omega,\mathbf{Q},\mathbf{P})$ with $||\mathbf{x}_0(\omega)||_{L_D(\Omega_1,\mathbf{P})}^{(\Omega_1,\mathbf{Q},\mathbf{P})} < \delta$, any a.e. solution $\mathbf{x}(t,\omega)$ to the above system with initial conditions t_0 and $\mathbf{x}_0(\underline{\omega})$ is extendable on $[t_0,\infty)$ and for any extension $\mathbf{x}(t,\omega)$ we have $||\mathbf{x}(t,\omega)||_{L_\infty(\Omega_1,\mathbf{P})} < \epsilon$ for $t>t_0$. $||\overline{\mathbf{x}}(\mathsf{t},\hat{\omega})||_{\mathrm{L}_{\mathbf{D}}(\Omega,\mathfrak{a},\mathrm{P})} < \epsilon \text{ for } \mathsf{t} \geq \mathsf{t}_{\mathsf{o}}.$

A STOCHASTIC INTEGRAL EQUATION IN A METABOLIZING SYSTEM. J. S. Milton* and C. P. Tsokos. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061
A stochastic formulation is presented for a

problem arising in general biochemical metabolizing systems which was previously considered in the deterministic sense. Within this formulation there arises the following random integral equa-tion of the Volterra type:

 $M(t;\omega) = M(0;\omega) e^{-ct} + \int_0^t R(\tau;\omega) e^{-c(t-\tau)} d\tau$ $t \ge 0$

where $M(t;\omega)$ represents the amount of metabolite present in the system at time t and $R(t;\omega)$ is the rate at which metabolite is entering the system from the outside at time t. The question of existence and uniqueness of a random solution to the above equation is considered using the techniques of admissibility theory.

SYSTEMS RELIABILITY USING GERTS III. <u>K. R. Morrison</u>* and K. E. Case*, Dept. of IEOR, Virginia Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061

The purpose of this paper is to show how the GERTS (Graphical Evaluation and Review Technique Simulation) program can be used to model the reliability of systems which are composed of non-repairable components. Large series-parallel networks and moderate non-series-parallel networks are often difficult to analyze analytically. GERTS is easily adapted to networks of components and system reliability may be determined. Examples of series-parallel and complex systems are presented.

FORMAL SOLUTIONS FOR A CLASS OF STOCHASTIC LINEAR PURSUIT-EVASION GAMES WITH PERFECT INFORMATION.
W. G. Nichols*, and C. P. Tsokos. Dept. of Statistics, Va. Polytechnic Inst. and State Univ.,
Blacksburg, Va. 24061
Consider the linear stochastic differential

pursuit-evasion game with transition equation

 $\frac{d}{dt} x(t;\omega) = P(t;\omega) u(t;\omega) - E(t;\omega) v(t;\omega) (1)$

 $x(0;\omega) = x_0(\omega)$ where (i) $\omega \in \Omega$, where Ω is the supporting set of the complete probability measure space (Ω, A, μ) ; (ii) $\begin{array}{l} \kappa(t;\omega) \, \epsilon L_2 \left(\Omega, A \mu \mu \right) \text{ is the state vector, } u(t;\omega) \epsilon \\ L_2 \left(\Omega, A, \mu \right) \text{ and } v(t;\omega) \epsilon L_2 \left(\Omega, A, \mu \right) \text{ are respectively} \\ \text{the pursuer's and evader's controls chosen at time} \\ \text{t for each } \omega \epsilon \Omega; \text{ and (iii) } P(t;\omega) \text{ and } E(t;\omega) \text{ are} \\ \text{matrices of measurable functions.} \end{array}$

matrices of mode be given by $J = \frac{1}{2} E(x'(T;\omega) S_f(\omega) x(T;\omega) + \int_0^T [u'(t;\omega) B(t) u(t;\omega) - v'(t;\omega) C(t) v(t;\omega)] dt)$ where termination time; (where (iv) T is some given termination time; (v) B and C are symmetric, positive definite matrices,

B and C are symmetric, positive definite matrices and $S_f(\omega)$ is a positive semidefinite matrix. Dividing the time interval [0,T] into N small subintervals of length Δ and assuming that Δ is small enough so that $\omega \epsilon \Omega$ does not change significantly during a subinterval, we have a series of N deterministic games whose solutions can be obtained.

OPTIMAL CONSUMPTION AND INVESTMENT STRATEGIES FOR A CLASS OF UTILITY FUNCTIONS. J. F. O'Connor*, Depts. of Econ. & Stat., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The decision problem faced by an individual who wishes to plan for the next T periods is analyzed. The utility function which is defined on sequences of consumption expenditures and terminal wealth is the product of single period constant relative risk aversion functions. The individual begins with a given amount of capital. He receives a known wage income at the end of each period. At the start of each period, capital is allocated between consumption, borrowing or lending at a known rate of interest, and N risky finan-cial opportunities. Borrowing is constrained by the condition that individual be solvent at the start of the next period with probability one.

The model is analyzed by the technique of dynamic programming. Optimal consumption expenditure in a given period is a linear and homogeneous function of capital at the beginning of the period and the present value of wage income. Optimal investment strategies depend only on the rates of return in the period and the relevant single period utility function. The optimal mix of risky investments is independent of wealth. Optimal borrowing and lending strategies are linear in capital and human wealth.

STOCHASTIC INTEGRAL EQUATIONS: THEORY AND APPLI-CATIONS IN LIFE SCIENCES AND ENGINEERING; STOCHASTIC CHEMOTHERAPY MODEL, POPULATION GROWTH MODEL, TELEPHONE TRAFFIC THEORY, TURBULENCE THEORY, HEREDITARY MECHANICS, AND STOCHASTIC CONTROL THEORY THEORY, THEORY TH

THEORY. W. J. Padgett and <u>C. P. Tsokos</u>, Department of Statistics, VPI&SU. The aim of this paper is to introduce the theory of stochastic integral equations and to apply this theory to various open problems in life sciences and engineering. We study stochastic integral equations of the forms

 $\mathbf{x}(\mathsf{t};\omega) \; = \; \mathbf{h}(\mathsf{t};\omega) \; + \; \boldsymbol{f}_0^\mathsf{t} \; \mathbf{k}(\mathsf{t},\tau;\omega) \, \mathbf{f}(\tau,\mathbf{x}(\tau;\omega)) \, \mathrm{d}\tau \, ,$

 $x(t;\omega) = h(t;\omega) + \int_0^t k(t,\tau,x(\tau;\omega))d\tau,$ where $\omega \epsilon \Omega$, the supporting set of a complete probability measure space (Ω,A,P) . $x(t;\omega)$ is the unknown random variable, $h(t;\omega)$ the stochastic free term and $h(t,\tau,\omega)$ is the stochastic kernel defined for $0 \le \tau \le t \le \infty$ and $\omega \in \Omega$. The usefulness of the theory is illustrated by solving specific problems in Biology, Telephone Traffic, Turbulence, Hereditary mechanics, control theory, among others.

MUTUAL INFORMATION, WEIGHT OF EVIDENCE, AND SINGULAR PROBABILITY MEASURES WITH APPLICATIONS TO COMMUNICATION THEORY. D.B.Osteyee, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24,061; Radford Col., Radford, Va.

Stationary gaussian stochastic processes de-fined over any interval under two competing hy-potheses are considered.

The expected weight of evidence in favour of one hypothesis over the other, given the former, will be infinite if and only if the probabilities

defined on these processes under the two hypotheses are mutually singular.

It is then possible to discriminate with arbitrarily small error between the two hypotheses by using the values of the processes over any arbi-

This paradox arises in certain models in communication theory when one is testing for signals in additive noise. In these cases it also follows that the rate of expected mutual information from a received signal about the original signal will be infinite.

These paradoxes will not arise for signals with finite power or variance if one accepts the fact that in practical situations there is always some type of white noise present.

VARIATION IN TURKEY NUTRITION EXPERIMENTS AND REQUIRED REPLI-CATION FOR DETECTING SMALL DIFFERENCES. L. M. Potter. Dept. of Poultry Science, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The results of several nutrition experiments conducted with turkeys at this university during the past decade have been evaluated to provide a basis for designing experiments more efficiently in the future. From 28 experiments each with 432 turkeys divided by sex into 48 pens and fed 24 diets for seven or eight weeks, the median square roots of the error mean square (sex x diets) were 4.6, 5.0 and 2.8% of the mean body weight, feed consumption and feed efficiency, respectively. Based upon these results, it would require 170, 200 and 42 pens per treatment with 9 turkeys per pen for a 1.0% difference in body weight, feed consumption or feed

efficiency, respectively, to be significant.

From 8 experiments each with 118 to 272 hen turkeys per experiment divided into 11 to 17 hens per pen, the coefficients of variation among pen averages for eggs per 100 days per hen, feed consumption per hen, feed consumption per egg produced, percent fertility of eggs set, percent hatch of fertile eggs, and percent hatch of eggs set were estimated to be 10, 5, 7, 11, 4.5 and 9, respectively. Based upon these estimates, the number of pens required in an experiment for any difference to be significant in these measurements can be calculated.

PROBABILITY AND STATISTICS IN HIGH SCHOOLS. Isabelle P. Rucker, State Dept. of Education, Richmond, Va. 23216

Prior to 1960, little if any probability and statistics could be found in the textbooks used in the schools. Today, some junior high school texts, especially those designed for the mathematically interested and talented students, contain as much as a chapter or two on probability. Generally, the topic is presented as "something different", as an interest attractor, and/or review of previously learned concepts and skills such as set operations, set language, set notation, and computation with rational numbers. Equally likely events are considered. Simple combinatorics and arrangements are given rather explicit treatment that lead to the factorial concept and its use. The following comments indicate, briefly, what is taking place in certain senior high schools with regard to probability and statistics: A two-semester course, "Computers and Statistics", is offered. Students learn computer programming so that they can use the computer as a tool in solving statistical problems. (2) A one-semester course in statistics is offered as an adjunct to analytic geometry. (3) Statistics comprised a considerable portion of a summer institute for high school students for four summers. (4) In a course, "Advanced Algebra", 50% of the content is probability. (5) Some schools, equipped with terminal computers and desk-top calculators, offer a two-semester course in probability and statistics. Students conduct independent research studies and submit statistical analyses for their findings.

AUGMENTING MULTIDIMENSIONAL DESIGNS. J. Sennetti* and K. Hinkelmann. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Multidimensional designs, such as Latin squares and other incomplete block designs, are usually constructed under the assumption that no interaction between the factors is present. In this paper, the assumption of no interaction is partly removed and a method is given for adding the miniremoved and a method is given for adding the minimum number of points necessary to such incomplete designs in order to estimate first order interaction contrasts between certain factors. This method can be used to construct resolution IV designs and other irregular fractions. Such minimal designs permit tests on interactions when an estimate of error exists or can be found and experimental units are at a premium.

SOME USES OF FACTOR MATCHING TECHNIQUES IN EXPLAINING SOCIAL CHANGE OVER TIME AND ACROSS COMMUNITIES. B.K. Singh, Dept. of Sociology, Virginia Commonwealth Univ., Richmond, Va.

Following the factor matching technique suggested by Ahmavaara (1957) and Fruchter and Jennings (1962), data from an Appalachian county were analyzed to explain social change across six communities and over two time periods. The findings indicated that such a technique did prove useful in explaining social change when aggregate data were used. (Contract #693 between University of Kentucky Research Foundation and the Office of Economic Opportunity). SYSTEM OPTIMIZATION THROUGH SIMULATION BY SUCCESSIVE

QUADRATIC APPROXIMATIONS. J. R. Smith* and J. W. Schmidt*. Dept. of Ind. Eng. and Op. Res., Va. Polytechnic Inst., Blacksburg, Va. 24061

The optimization procedure, successive quadratic approximations, is discussed. Cost based termination criteria are given. The performance of the technique and termination criteria are evaluated on example problems. and termination criteria are evaluated on example problems. Included in the examples are the minimization of the expected value of mathematical functions with error and the minimization of the expected value of total cost of a simulated inventory system.

GRADIENT METHODS FOR THE SOLUTION OF NON-LINEAR PARAMETER ESTIMATION PROBLEMS. Terry A. Straeter*, NASA Langley Research Center, Hampton, Va. 23365

Several classes of gradient methods for the solution of certain nonlinear parameter estimation problems are outlined. Among the methods discussed are the Gauss-Marquardt, Davidon-Fletcher-Powell, and rank one techniques. The results of several researchers including the author comparing the reliability and efficiency of the methods are presented.

THE ECONOMIC OUTLOOK. L. E. Traywick*. Bureau of Business Res., College of William and Mary, Williamsburg, Va. 23185

The recovery of the U. S. economy from the recession of 1969-1970 will be slow. Unemployment will persist between 5.5 and 6.0 percent, inflation will remain near the 5.0 percent level, and growth in real Gross National Product will not approach the Nixon Administration's hoped-for 7.5 percent, but will be closer to the 3 percent level. Thus, 1971 will be a better year than 1970, but not an ebullient one.

Influential factors to watch are fiscal, monetary, and the psychology of the consumer. Of the three financial influences (spending by consumers, by business for investment, and by the government), by far the most important is consumption. Of significance will be the increases in incomes of consumers as well as the employment situation, the rate of inflation, savings, installment debt changes, and above all consumer sentiment. The latter remains sluggish if auto sales are

Business investment spending for new plant and equipment remains considerable below the rate of change for the past $% \left\{ 1\right\} =\left\{ 1\right\}$ three years. Only new private housing starts are buoyant.

Capacity expansion and concomitant new jobs remain slow. Government spending at the federal level proceeds with the high employment budget in surplus as fear of re-inflating the economy persists. State and local spending surges.

Increases in the money supply have done everything thus far possible to stimulate the economy. Without increases in business loans, however, little will avail.

SOME MULTI STEP SEARCH PROCEDURES FOR UNCONSTRAINED OPTIMIZATION. W.C. Turner*, and P. M. Ghare*, Dept. of Ind. Eng. and Opr. Res., Va. Polytechnic Inst. and State University. 24061

Single step directional search methods are discussed from a relaxation point of view leading to the developement of Incomplete Relaxation. This then is extended to incorporate multi step concepts borrowing heavily from residual methods for solutions of simultaneous linear equations. Next some well known mathematical functions are solved using complete relaxation, incomplete relaxation and multi step techniques. Finally suggestions are made for applications of these methods.

News and Notes

VIRGINIA JUNIOR ACADEMY OF SCIENCE AWARDS

At the 30th annual meeting of the Virginia Junior Academy of Science, held at Virginia Polytechnic Institute and State University in Blacksburg, May 11–13, 1971, the following awards were presented. Philip Morris Achievement Awards for Winning Papers: Recipients are listed in order of awards, first place (\$50.00), second place (\$25.00), and third place (\$10.00). Honorable mention awards also were made.

MOLECULAR BIOLOGY GUNN, JENNIFER: John Marshall High School, Richmond (Richmond City School System). Growth and Morphogenesis of Three Physiologically Distinct Isolates of Candida albicans; NICHOLSON, JOY: Gunston Junior High School, Arlington (Arlington County School System). Tooth Decay: Causes and Prevention; LANG, ROGER B.: Lane High School, Charlottesville (Charlottesville City School System). Determining Calories in Different Types of Breads.

DEVELOPMENTAL BIOLOGY KISER, JOY DE-VONNA: John S. Battle High School, Bristol (Washington County School System). The Effects of Heat Shock on Bean Germination; PETERSON, CHERYL: Gunston Junior High School, Arlington (Arlington County School System). The Effects That Acids and Lanolin Have on Bean Seeds; SWAN, WILLIAM J.: Norfolk Academy, Norfolk (Private School). Shell Relationships Among Littorina irrorata in Various Stages of Development.

ORGANISMIC BIOLOGY COX, LINDA: William Byrd High School, Vinton (Roanoke County School System). Chemical Retardants for Salt Toxicity; LANIER, LEWIS: J. R. Tucker High School, Richmond (Henrico County School System). A Study of the Sulfur Requirements of Chlorella; ROBINSON, BILLY: Patrick Henry High School, Ashland (Hanover County School System). The Lethal Effect of Various Concentrations of Ampicillin Trihydrate on Selected Microscopic Plants and Animals.

POPULATION BIOLOGY JACKSON, DELLA L.: Liberty High School, Bedford (Bedford County School System). The Effects of Ionizing Radiation on the Growth of Plants; MURPHY, PAULA: Norfolk Academy, Norfolk (Private School). The Effect of an Electromagnetic Field on Growth and Respiration of Sugar Beets and Radish Seeds; MAYFIELD, DAVID W.: William Byrd High School, Vinton (Roanoke County School System). The Effects of Lifelite Filtered Light on Plants.

BEHAVIORAL SCIENCE CLARK, JONATHAN: Fort Hunt High School, Alexandria (Fairfax County School System). A Comparative Analysis of Sonic Emissions from the Blind Cave Fish and Talking Catfish; RASTETTER, EDWARD

and JOHN EVANS: York High School, Yorktown (York County School System). An Experiment in Kinesics; WARD, BARBARA: Hampton High School, Hampton (Hampton City School System). Biological Clocks in *Una pugilator* as Evidenced by Color Change and Running Rhythms.

ENVIRONMENTAL SCIENCE EASTHAM, WILLIAM A.: Warren County High School, Front Royal (Warren-Rappahannock County School System). Ecology: Environmental Pollution; HOOKEY, CHARLES: Warren County High School, Front Royal (Warren-Rappahannock County School System). Particulate Air Pollution in Warren County, Virginia; TAYLOR, DAN: Radford High School, Radford (Radford City School System). The Effects of DDT on Photosynthesis.

CHEMISTRY BENDER, BARRY: James Madison High School, Vienna (Fairfax County School System). General Applications of a Homemade Silver-Silver Chloride Electrode and a Calomel Electrode; WESCHKE, FRANK: Radford High School, Radford (Radford City School System). The Effects of Detergents on Crystal Growth; CHESSON, EDWIN E. and JOSEPH C. FARMER: Floyd County High School, Floyd (Floyd County School System). Synthesization of Amino Acids.

ENGINEERING GREGORY, LEE: Warwick High School, Newport News (Newport News City School System). Design and Construction of an Expandable Binary Coded Decimal Computer; PILLS-BURY, JOHN F.: West Springfield High School, Springfield (Fairfax County School System). Color Photography and an Electronic Photometric Device: A "Negative-Inverter"; SCHWEBS, MONICA: Stratford Junior High School, Arlington (Arlington County School System). 1 + 1 = 10 Digital Computer Basics.

MATHEMATICS NAKATSUKA, ROY: Gunston Junior High School, Arlington (Arlington County School System). An Investigation of Modular Mathematical Systems; KROUT, JOHN: Washington-Lee High School, Arlington (Arlington County School System). Extension of Fortran IV Digital Precision; JONES, EDWINA: Liberty High School, Bedford (Bedford County School System). Charged Particles: A Model for Teaching Directed Numbers.

PHYSICS MARTIN, THOMAS MILLER,. JR.: Liberty High School, Bedford (Bedford County School System). Vortex Separation of Kinetic Energy for Thermodynamics; LEIGHTON, TOM: Stratford Junior High School, Arlington (Arlington County School System). Building a Galvanometer and Using It to Measure Current, Potential, Resistance and Temperature, and to Detect the Thermoelectric Effect, Electromagnetic Induction, and Electromagnetic Radiation; STEMPLE, JOHN:

Falls Church High School, Falls Church (Fairfax County School System). Optical Rotation by a Magnetic Field.

EARTH SCIENCE BROWNE, DANA: McLean High School, McLean (Fairfax County School System). A Photoelectric Study of Delta Cephei; DEAS, LYNN: Homer L. Ferguson High School, Newport News (Newport News City School System). The Effects of the James River Water Currents on Its Sediment; BARLEY, STEPHEN: John Handley High School, Winchester (Winchester City School System). Geographical Location as a Factor in Determining Specific Heat of Rocks.

The following special awards were presented: Best Research Paper-1971 (\$50.00) PILLSBURY JOHN R.: West Springfield High School, Springfield. Color Photography and an Electronic Photometric Device: A "Negative-Inverter."

Rodney C. Berry Chemistry Award (\$50.00) BENDER, BARRY: James Madison High School, Vienna. General Applications of a Home-made Silver-Silver Chloride Electrode and a Calomel Electrode.

Virginia Veterinary Auxiliary Award (\$50.00) GUNN, JENNIFER: John Marshall High School, Richmond. Growth and Morphogenesis of Three Physiologically Distinct Isolates of Candida albicans.

AAAS Honorary Membership Award DEBBIE MELOY: W. T. Woodson High School, Fairfax.

VAS Honorary Membership Award TOM MUR-RAY: Norfolk Academy, Norfolk; and JOHN KROUT: Washington-Lee High School, Arlington.

E. C. L. Miller Award to Most Outstanding Science Club (\$50.00 and trophy) LIBERTY HIGH SCHOOL SCIENCE AND MATHEMATICS CLUBS: Liberty High School, Bedford.

VAS Outstanding Teacher Award DONALD O. BUTTERMORE; Gunston Junior High School, Arlington.

Trip to American Junior Academy of Science Meeting LEE GREGORY: Warwick High School, Newport News; and DANA BROWNE: McLean High School, McLean.

VIAS Distinguished Service Award. MRS. MARTHA LIPSCOMB WALSH (retired): McLean High School, McLean.

A total of 342 papers were submitted, of which 200 were selected for oral presentation. A total of 61 schools submitted papers; 53 had papers selected. The top 33 winning papers (first, second, and third) came from 24 different schools. Liberty had two firsts and a third, and Gunston Junior had one first and two seconds to lead the list. Ten first place papers were presented before the Senior Academy sections. Molecular Biology did not show.

The 1971–72 student officers elected were: President, George E. Rector, Jr., Brentsville District High School; President-elect, Frank Key, Liberty High

School; and Secretary, Brenda Bowers, Floyd County High School.

AWARD PROGRAM FOR SECONDARY SCHOOL PHYSICS TEACHERS

The American Association of Physics Teachers will continue the Award Program for teachers of physics on the high school level for the year 1971.

The emphasis of the program—innovation in teaching style, course content, or student recruiting techniques—reflects the conviction among educators that the conventional approaches must be modified to accommodate the growing demand for an education that is relevant to a changing society. With this in mind, the officers of AAPT feel it is most appropriate to reward, in a substantial way, individual high school teachers who have instituted needed changes in their physics programs resulting in significant improvements in their physics courses, demonstrable increases in physics enrollment, or enhanced student activity. Emphasis will be placed on the novelty and effectiveness of the change.

If you are a high school physics teacher, submit your entry postmarked not later than October 15, 1971, to Wilber Johnson, Executive Officer, AAPT, 1785 Massachusetts Avenue, N.W., Washington, D.C. 20036. Your entry should not exceed 1200 words in length (exclusive of supporting graphs, tables, and photographs). It should describe a change in some aspect of the physics program at your school which you helped to implement. The article must include evidence for either improved student academic performance or increases in physics enrollment which are attributable to the changes described.

The Executive Officer will forward all entries to the AAPT High School Awards Committee. This Committee will read and rank the entries on the basis of the selection criteria discussed previously.

The teachers submitting the ten most highly rated papers will be visited by a member of the AAPT. Visitors will submit reports for a second round of judging; each judge will vote for five entries which he believes merit a cash award. The five individuals receiving the highest number of votes on this ballot will be the recipients of awards of \$500 each. In addition, all winning entries will be published in THE PHYSICS TEACHER. The presentation of awards will be made at the annual winter AAPT meeting (San Francisco, February 1972). Funding for the program, which has been provided by the Carnegie Foundation, is sufficient to maintain this program for at least three more years.

Any questions about the program should be directed to the Executive Officer of the AAPT.

VUU GRANTS

Virginia Union University, Richmond, Virginia, was one of 20 private colleges and universities with predominantly black enrollments to share in a \$4, 500,000 appropriation from the Andrew W. Mellon Foundation of New York City. The \$200,000 grant is to be disbursed over a period of three years. The objective of the grant is to help strengthen the selected institutions generally and the quality of their teach-

ing staffs in particular. The Andrew W. Mellon Foundation was formed through the merger of Old Dominion Foundation in June, 1969, the name of the latter having been changed concurrently to the

present designation.

Virginia Union University has also received a grant of \$121,041 to sponsor a career opportunities program. It is planned to improve the educational achievement of young people through curriculum development and the open-classroom approach. Tuition-free courses will be provided for all persons enrolled in the program. This program will be in addition to the one currently sponsored by the Richmong Public Schools through cooperative efforts with the University. The program is unique because two other educational enterprises will be involved. Virginia State College in Petersburg will be responsible for all work beyond the baccalaureate level. The Institute for Services to Education in Washington, D.C., will serve as a resource service for the program.

UVA SIGMA XI

An associate professor of chemistry, a postdoctoral research associate in chemistry and a graduate student in biology were recipients of awards presented at the annual meeting of the University of Virginia chapter of the Society of Sigma Xi in May.

Dr. Lester S. Andrews, associate professor of chemistry, was the 1971 recipient of the President's and Visitors' Research Prize for outstanding research in pure and applied science. Dr. Andrews, whose research subject this year was "Infrared Spectrum Structure, Vibrational Potential Function and Bonding in the Lithium Superoxide Molecule," also won

the prize in 1969.

Dr. Susan Brand Piepho of Amherst, Virginia, a postdoctoral research associate in chemistry, was the 1971 recipient of the Allan Talbott Gwathmey Award, while Bruce H. Lipton of Charlottesville, a graduate student in biology, received the Andrew Fleming Prize. The Gwathmey prize goes to a graduate student who has produced evidence of research ability, and the Fleming award recognizes the outstanding graduate student in biology each year. Dr. Peipho was cited for research done last year as a graduate student in which she analyzed magnetic circular dichroism and electronic absorption data of highly symmetrical inorganic compounds. Lipton's research centers around elucidating the structure of developing muscle cells in tissue culture.

Honorable mention for the President's and Visitors' Research Prize this year went to Dr. Charles S. Chen, assistant professor of mechanical engineering, for a paper written with Dr. M. M. El-Wakil of the University of Wisconsin on "Experimental and Theoretical Studies of Burning Drops of Hydrocarbon Mix-

tures."

Twenty-two new members and 53 associates were initiated into the University chapter of Sigma Xi.

VCU SIGMA XI

Dr. Seymour J. Kreshover, director of the National Institute of Dental Research, spoke on "Dentistry 2000: Big Changes Ahead" at the May 6 meeting of the Virginia Commonwealth University chapter of the Society of the Sigma Xi. Among the advances Dr. Kreshover forecasted for dentistry of the future are revolutionary methods to heal wounds, better understanding and control of genetic makeup to prevent oral malformations, common use of dental transplants and implants, and regulation of the body's natural defense system as an aid to therapy.

Twenty new members and six associates were initiated into the VCU chapter of the Society of the Sigma Xi. Dr. Kenneth E. Guyer, Jr., assistant professor of biochemistry at the Medical College of Virginia, was elected president of the Virginia Commonwealth University chapter for next year. Other new officers are Dr. William Stepka, professor of pharmacognosy in the School of Pharmacy, vice president, and Dr. Edward R. Bowman, research associate in pharmacology, as secretary-treasurer.

MCV APPOINTMENTS

Dr. Warren H. Pearse, assistant dean for the College of Medicine of the University of Nebraska, has been appointed dean of the School of Medicine at the Medical College of Virginia, Health Sciences Division of Virginia Commonwealth University, effective in November, 1971. Dr. Pearse succeeds Dr. Kinloch Nelson as dean of medicine. Dr. Nelson retired on July 1 after more than 40 years on the MCV faculty, the last eight years as dean of the School of Medicine.

A native of Detroit, Mich., Dr. Pearse has been a member of the University of Nebraska College of Medicine faculty since 1959. He was appointed professor and chairman of the Department of Obstetrics and Gynecology in 1962 and was named assistant dean of medicine in 1963. Dr. Pearse received the B.S. degree from Michigan State University in 1948 and his M.D. degree from Northwestern University in 1951. He interned and completed residency in obstetrics and gynecology at the University of Michigan Hospitals and was certified in 1960 by the American Board of Obstetrics and Gynecology. He is a member and 1970-71 chairman of the National Children's Bureau Research Grant Advisory Council, an associate examiner of the American Board of Obstetrics and Gynecology, a member of the residency review committee for ob-gyn, and a member of the Food and Drug Administration Obstetrics-Gynecology Advisory Committee. He also is an ob-gyn consultant to the U.S. Fifth Army and family planning consultant to the Office of Economic Opportunity Population Council.

Dr. Pearse is a member of Alpha Omega Alpha, Sigma Xi, the American College of Obstetrics and Gynecology, and current secretary-treasurer of the Association of Professors of Gynecology and Obstet-

rics.

Dr. F. Norman Briggs, professor of physiology at the University of Pittsburgh School of Medicine, has been appointed professor and chairman of the Department of Physiology. A member of the University of Pittsburg medical faculty since 1961, Dr. Briggs also has been on the faculties of Tufts University School of Medicine, Harvard Medical School, and the Harvard School of Dental Medicine. A native of Oakland, Calif., he received his A.B., M.A., and Ph.D. degrees from the University of California. In 1955-56 Dr. Briggs was recipient of a U. S. Public Health Service Research Fellowship for study of muscular contraction with H. H. Weber at Max-Planck Institut fur Medezinische Forschung. He was awarded a Public Health Service Research Career Award from the National Heart Institute in 1964 and the Established Investigator award from the American Heart Association, 1960-64. Dr. Briggs is a member of the Society for Pharmacology and Experimental Therapeutics, the American Physiological Society, the Cardiac Muscle Society, and the study section for physiology training programs of the U.S. Public Health Service.

Dr. Giovanni G. Costa has been appointed professor of medicine and director of the Clinical Research Center. The Center is a special unit founded in 1962 to conduct detailed research procedures in a controlled environment. Sponsored by a grant from the National Institutes of Health, it is one of a number of clinical research units established at medical centers throughout the country to enable physicians to learn more about disease, how it affects individuals, and

how it can be treated.

Special studies at the MCV center include kidney, heart and liver transplantation and immunology as well as work in diabetes, high blood pressure, and eye and skin infectious diseases. Dr. Costa succeeds Dr. W. R. Harlan, Jr., as director of the MCV Clinical Research Center. Before joining the MCV staff, Dr. Costa was an assistant professor of medicine at State University of New York at Buffalo. He was a member of the cancer research staff at Roswell Park Memorial Institute, 1960-65. Dr. Costa is a native of Collagna, Italy, and received his medical degree from the University of Genoa Medical School. He has a Ph.D. in biochemistry from the University of Oklahoma. His post-graduate training included work at Peter Bent Brigham Hospital in Boston.

UVA APPOINTMENTS

Dr. W. Dexter Whitehead, past chairman of the Academy's Research Committee, became dean of the Faculty of Arts and Sciences at the University of Virginia July 1. Dr. Whitehead will also continue his present position as dean of the Graduate School of Arts and Sciences at the University. The combined appointment is for one year.

"The University is greatly indebted to Mr. Whitehead for his willingness to undertake an additional major responsibility this year, and it is fortunate to have available a scientist, teacher and administrator of such broad and distinguished experience," University President Edgar F. Shannon, Jr., said in announcing the appointment.

Dr. Whitehead succeeds Dr. David A. Shannon who became vice president and provost of the University on July 1. The dean of the faculty is the chief adviser to the provost and the president of the Uni-

versity on courses of study in graduate and undergraduate arts and sciences and also recommends additions to the faculty. Of the University's enrollment last year of 10,800 students, more than half were enrolled in arts and sciences. In the Graduate School of Arts and Sciences, Dr. Robert F. Bryan, associate professor of chemistry, will serve as associate dean for admissions. Dr. Samuel P. Maroney, Jr., associate professor of biology, will be assistant to the dean.

Dr. Whitehead, who received his B. S. degree in chemistry and his M.S. and Ph.D. degrees in physics from the University of Virginia, is noted for his work on neutron scattering experiments and photonuclear reactions. He joined the University faculty in 1956 after working at the Barton Research Foundation in Swarthmore, Pa., and teaching at North Carolina State College. Before being named dean of the graduate school in 1969, he was chairman of the physics department. Dr. Whitehead also directs the University's Center for Advanced Studies which was established in 1965 to help the University strengthen its academic departments.

Dr. W. Gayle Crutchfield, professor of neurological surgery at the University's School of Medicine and former department chairman, and Dr. Yintang Hsu, professor of pathology at the medical school, have been named professor emeritus by the University Board of Visitors. They retired June 30. The rank of professor emeritus honors certain full professors, retiring between the ages of 65 and 70, who have

served the University for at least 15 years.

A native of Henry County, Ky., Dr. Crutchfield received his B.S. degree from the University of Kentucky in 1923 and his M.D. degree from the Johns Hopkins University in 1927. After service at the Woman's Hospital, Baltimore, Peter Bent Brigham Hospital, Boston, and the Medical College of Virginia, he went to the University as professor of neurological surgery and department chairman in 1941. He is author of a number of scientific papers dealing with various phases of neurological surgery and the developer of several important innovations for the treatment of fractures and fracture dislocation and is a former vice president of the American Association of Neurological Surgeons.

Dr. Hsu was born in Tung-kun, Kwang-tung, China, and received his M.D. degree from the Peking University School of Medicine in 1923. After a career in China which included a professorship in pathology at Hunan Yale Medical College, he went to the University as visiting professor of pathology and resident pathologist in 1945. A specialist in surgical pathology and the author or coauthor of more than 30 scientific papers, Dr. Hsu has concentrated on tropical, infectious, parasitic and fungoid diseases and will continue his research with members of the department of dermatology on tissue changes. He was named pro-

fessor of pathology in 1970.

Dr. Kenneth R. Crispell, formerly dean of the School of Medicine, was promoted to the position of vice president for health sciences effective March 1, 1971. Dr. Crispell succeeds Dr. Thomas H. Hunter as the top medical administrative officer under President Shannon. Dr. Hunter is returning to fulltime teaching and research as Owen R. Cheatham Professor of Science.

As a vice president, Dr. Crispell will be responsible to Dr. Shannon for the administration of the entire area of health affairs in the University's Medical Center including its 600-bed teaching hospital, the schools of medicine and nursing and related programs. In appointing Dr. Crispell as one of his five vice presidents, President Shannon said Dr. Crispell's "distinguished work as dean has conspicuously enhanced the quality of the School of Medicine and increased its capacity to advance medical science and education and to serve the public."

Dr. Crispell, a native of Ithaca, N. Y., first joined

the University in 1949 as instructor in medicine and became an assistant and then associate professor of medicine. In 1960, he returned to the University after two years as professor of medicine and chairman of the department at New York Medical College. He was appointed dean in 1964. He is on the executive council of the Association of American Medical Colleges and a member of the Duke University Medical Center Board of Visitors. He has served on the Governor's Advisory Committee for Virginia Regional Medical Programs and is currently on the Governor's Study Commission for Medical Facilities in Roanoke. A graduate of Philadelphia College of Pharmacy and the University of Michigan School of Medicine, Dr. Crispell has received distinguished alumni awards from the college and the Ochsner Clinic in New Orleans where he interned.

Dr. James T. Hamlin III has been named acting dean of the School of Medicine to fill the vacancy created by Dr. Crispell's promotion. He has been assistant dean since 1969. A native of Danville, Dr. Hamlin is a graduate of Virginia Military Institute and received his M.D. degree from the University of Virginia. He interned and was later assistant in medicine at Peter Bent Brigham Hospital in Boston and then was a research fellow at Harvard Medical School. He joined the University medical faculty in 1966 as associate professor of medicine after teaching at New York Medical College and the Medical College of Georgia. Dr. Hamlin also directs the Medical Center's 10-bed clinical research unit where investigations into the cause and effects of human disease problems can be carried out under precisely controlled conditions.

Dr. Samuel E. Miller, currently in private practice in Abingdon, in September will become professor of family and community medicine in internal medicine.

Eugene H. Brock, who is presently deputy assistant director for computation and flight support at the NASA-Manned Spacecraft Center in Houston, Texas, will become director of computing activities at the University and director of the Region II computing center for the State of Virginia. He will also hold an appointment as professor of electrical engineering in the School of Engineering and Applied Science. Brock received his bachelor's degree from Texas Technological College and his master's from Texas A & M University, where he served as assis-

tant dean of the School of Engineering. Before joining the National Aeronautics and Space Administration, he managed the computer center General Electric Company at the Marshall Space Center.

In his new position Brock will have prime responsibility for the University's three main computer centers—administrative data processing, computer-science and medical—and for arranging and coordinating, in conformance with the Virginia Plan for Educational Data Processing, computer services required by the 20 colleges and universities served by the State in Region II. As new director, Brock will be responsible for future expansion and plans for the University's consolidated computer services. He will be advised by the University com-

mittee on automated data processing.

Computing facilities at the University have been expanded recently with the installation in May of a Burroughs 2500 in the Medical Center. The new computer has increased computing capability 10 times and is designed to support a general hospital information system. Drug orders, patients' records, bills and lab reports are among the items which will be handled by the new computer. Dr. Donald J. Wright is director of the Medical Center computing center. Arrangements have also been completed for the leasing of a new research computer to be installed in the computer science center in Gilmer Hall. Valued at \$2 million, the high-speed CDC 6400, manufactured by Control Data Corporation, is particularly designed for the kinds of problems encountered in scientific calculations. It is expected to be at least five times faster than the present Burroughs 5500 which is used extensively for instruction and research projects by undergradate and graduate students as well as the faculty research. Dr. Alan P. Batson is director of the computer-science center.

Dr. A. Wayne Wyman, an expert in systems engineering, will be visiting professor of aerospace engineering. He is now professor at the University of Arizona. Also to be a member of the Center for Advanced Studies, Dr. Kurt Meyberg will be visiting associate professor of mathematics. Currently associate professor at the University of Munich and Munster in his native Germany, he specializes in Jordan algebras. Others appointed to the Center for Advanced Studies include Dr. Nils A. Baas, an algebraic topologist now a lecturer at the University of Aarhaus in Denmark, who will be visiting assistant professor of mathematics, and Dr. Leonard L. Scott, to be associate professor of mathematics. Dr. Scott, whose field is group theory, is currently assistant professor at Yale University.

Effective September 1, Dr. Robert Ellison, associate professor of environmental sciences, will be chairman of that department.

VIMS APPOINTMENTS

Four new appointments have been made by Governor Holton to the board of the Virginia Institute of Marine Sciences. Each will serve four-year terms.

Carter O. Lowance, executive vice president at the College of William and Mary, replaces Dr. Davis Y. Paschall, president of the college.

Dr. W. Dexter Whitehead, dean of the graduate school of arts and sciences at the University of Virginia, replaces Dr. Edgar F. Shannon, president of the university.

Gilbert L. Maton of Falls Church, president of a scientific research and engineering laboratory at

Rockville, Md., replaces Fred Garrett of Bowlers Wharf.

Roger G. Hopper of Saluda, a lawyer and attorney for the town of Saluda, replaces former state Sen. Marvin Minter of Mathews, deceased.

Drs. Shannon and Paschall and Mr. Garrett were ineligible for reappointment.

EXHIBITORS

VIRGINIA ACADEMY OF SCIENCE ANNUAL MEETING Blacksburg, May 1971

- American Optical Corporation, Scientific Instrument Division, 7961 Eastern Avenue, Silver Spring, Maryland 20795
- Arthur H. Thomas Company, Third at Vine Street, Philadelphia, Pennsylvania 19105
- Bausch & Lomb, Inc., 349 Lancaster Avenue, Haverford, Pennsylvania 19041
- Bunton Instrument Company, Inc., 489 South Stonestreet Avenue, Rockville, Maryland 20850
- Carolina Biological Supply Company, Burlington, North Carolina 27215
- Fisher Scientific Company, 7722 Fenton Street, Silver Spring, Maryland 20910
- Gilson Medical Electronics, Inc., 3000 West Beltline Highway, Middleton, Wisconsin 53562
- Houghton Mifflin Company, 666 Miami Circle, N.E., Atlanta, Georgia 30324

- Phipps & Bird, Inc., Sixth and Byrd Streets, Richmond, Virginia 23219
- Polaroid Corporation, 1501 Wilson Blvd., Arlington, Virginia
- Sargent-Welch Scientific Company, 35 Stern Avenue, Springfield, New Jersey 07081
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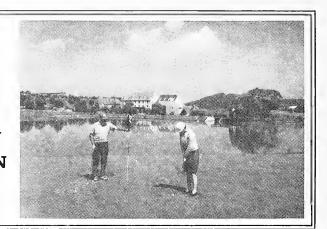
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The Science Museum of Virginia

More than a quarter-century ago a five-member Museum of Science Advisory Commission reported to the Governor and General Assembly of Virginia that "few agencies can be devised to advertise what we have to offer ourselves, or others, and to direct the interests of both young and old in building a greater Virginia than . . . a properly set up and administered State museum of science."

These men, two of whom—Dr. George W. Jeffers and Dr. William T. Sanger—remain active museum supporters, of vision and imagination called for the museum to be functional, both within and without its building, in a dynamic, educational way; becoming a real science center, "a veritable beehive of activity for all classes."

Today, their dream, carefully nurtured and enlarged by thousands of interested individuals and hundreds of groups and organizations throughout

Virginia, stands on the threshold of reality.

Spearheaded by the Virginia Academy of Science and other learned organizations, a comprehensive Museum Study Commission report in 1969 was the basis for concrete action by the General Assembly in 1970. Prior to that several efforts to effectuate the museum were unsuccessful.

Senate Bill No. 8 created the Science Museum of Virginia, outlined its purposes, and authorized appointment of a nine-member Board of Trustees. An operating budget for the 1970–72 biennium also

was approved.

Trustee appointments were completed by the Governor in February, 1971, and the selection reflects probably the most diverse geographic representation of any state institution. Board members include: Dr. Roscoe D. Hughes, Richmond, chairman; Dr. T. Dale Stewart, McLean, vice chairman; Mrs. William A. Stuart, Jr., Rosedale, secretary; Mrs. J. T. Bird, Salem; Dr. Avery Catlin, Charlottesville; Lyons Davidson, Lynchburg; Mrs. William T. Reed, Jr., Manakin-Sabot; Harold Soldinger, Norfolk; and William J. Vaughan, Virginia Beach.

Since March they have been formulating the basic concepts of a statewide museum system, and these efforts are reflected through many positive

policy decisions. For example, the Board has:

* Agreed that the museum system should include facilities in three or four population centers around the state; that "outreach" centers (existing structures such as small nature museums or community colleges) would be used for display of exhibits and collections on a temporary basis; that mobile units would be utilized to make periodic visits to areas without adequate display space; and that educational television would supplement all these to carry the message of science to all corners of the state.

* Approved an appropriations request of \$432, 197 from the state for the 1972–74 biennium. These funds would be used primarily for employment of a skeletal professional staff, acquisition of the necessary space for the storage and cataloguing of exhibits, dis-

plays, and collections for later use in the muscum system, and for master planning. Development of a total master plan, to include the type of museum facility for each proposed location, would provide the foundation for the entire system.

Set a fund raising goal of \$5 million during 1972–75 to supplement state revenue. The Board will look to foundations, corporations, and other private sources; the Federal Government; and localities that have expressed

an interest in a muscum facility.

* Launched a preliminary feasibility study of sites in three areas—Lynchburg, Norfolk, and Roanoke—to determine land availability. Similar studies are expected for Richmond and Portsmouth, following presentations by each city in the fall.

"Local enthusiasm has been extraordinary," Dr. Hughes has stated, "and the Board is keenly awarc of this spirit of cooperation." He further indicated that site evaluations being done now are for planning purposes only, and by "no means intended as final determinations."

Along with the local interest, various groups and organizations on the state level have indicated support for the museum program. Edward S. Harlow recently was appointed chairman of the VAS Science

Museum Advisory Committee.

As part of its broad information program, advisory committees also are being organized within communities seeking a museum facility, and the Board welcomes comments and suggestions from all interested citizens.

Each initial museum facility would provide a different feature, as directed by the enabling legislation, and each would be carefully designed to ensure a harmonious relationship between the structure and the natural environment. Along with education, major emphasis is placed on the museum's role in the field of ecology.

Approved by the General Assembly are:

* Physical Sciences—To include a planetarium and depict the history, concepts, and basic principles of such sciences as physics, chemistry, astronomy, and mathematics.

* Botanical Sciences—Primarily to educate in the kinds and uses of Virginia flora, and demonstrate the need for new horticultural

varieties in the state.

* Natural History—Would be devoted primarily to Virginia's natural resources, as well as paleontological and archeological artifacts and specimens.

 * Industry and Technology—To communicate the history, evolution, and development of

Virginia's industry.

* Oceanography and Limnology—To include an oceanarium and be concerned with Virginia's total aquatic life and its environment.

* Zoological Gardens—For the preservation of wildlife and viewing in their natural habitat.

Nyle C. Brady

Associate Dean,
New York State College of Agriculture
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Ithaca, New York 14850

The Role of Agriculture in Improving Environmental Quality*

I am continually amazed and not a little appalled at the depth of public ignorance and misunderstanding in regard to agriculture's relationship with the environment. For many years now, we have worked hard and long to shore up our public relations with our urban neighbors by trying to explain what modern commercial agriculture is and what it means to national welfare and abundance. On any other occasion I would be reluctant to state that agriculture may be doing too good a job; but on reflection we may very well have done too well in some areas.

Specifically I refer to the pains and efforts we have gone to in describing modern agriculture's high degree of specialization and technology. We have bragged of high producing monoculture and the inputs of fertilizer and pesticides that such type of farming requires. We have boasted of lean, high-quality beef produced under the carefully-controlled conditions of giant feed lots, and we speak freely of mass-produced broilers and the egg factories where 30 thousand or more hens may be housed under one roof and a million in a complex of roofs—close by to consumer marketing centers.

I submit that these publicity efforts have succeeded all too well, and now we find agriculture very close to where the environmental action is. By explaining so fully our dependence on pesticides, our waste disposal problems, and our need for efficiency through mass production, the public knows all too well where to find somebody to blame for at least some of our environmental quality problems.

Agriculture's Bad Environmental Image

Agriculture's image as an enhancer of environmental quality is not good. A brief review of recent history bears out this conclusion. The ill-timed announcement on November 9, 1959 that cranberries carried traces of the herbicide aminotriazole was the beginning. The condemning of this crop by the Secretary of Health, Education and Welfare made sensational headlines. It called the attention of society to the troublesome characteristics of the wonder chemicals that had revolutionized agriculture. Pesticides became an unpopular term known to the housewife, the man in the street, and the youngster in the school room.

The environmental image of agriculture was further damaged in 1962 by the dedicated but gentle naturalist-author Rachael Carson. Her Silent Spring (1) depicted in a realistic manner other side effects of these wonder chemicals. Although many of her accusations were unproven, she dramatically called attention to the innocent non-target organisms which may be affected by pesticides. Ten years later, scientists have verified her conclusions for some chemicals such as DDT and refuted them for most of the others. The accuracy of her accusations is probably less important than the change in attitude she engineered. Birds, fish and other wildlife for the first time were brought into the benefit:cost equation respecting pesticide use.

Rachael Carson brought into focus the excessive persistence of DDT and other chlorinated hydrocarbons and the tendency of these chemicals to build up in tissue of organisms as they are passed along the food chain. Unfortunately, public concern engendered by her and the many who agreed with her tended to eclipse the remarkable benefits from pesticides. Just as important, emotion and fear were human reactions which replaced confidence as it relates to pesticides and in fact to all man-made chemicals not having originated in nature.

Let us turn our attention to agriculture's bad image as witnessed by the urban spectator standing downwind of the hog lot or one of those egg factories referred to earlier. Our urban cousin, in driving his 300 horsepower auto out into the country, may have had a convenient seizure of tunnel vision or plugged nasal passages as he drove by the factory where he works and the municipal sewage plant that serves his city. But these seem not to be relevant when one is seeking to get back to nature in the countryside.

At any rate, if the effects of agricultural waste runoff are not readily visible to our urbanite, his nose will soon inform him of another modern-day agricultural problem—what to do with animal manure? Again, we have a commentary on the changing stance of commercial agriculture.

For centuries, the conservation and enthusiastic use of livestock and poultry manure was a canon of good husbandry of the soil. Before the dawn of scientific agriculture, manure was regarded as "goodness" and as an essential ingredient of soil enrichment, absolutely necessary to the successful production of crops. Homer's "The Odyssey," written prior

^{*} Sidney S. Negus Memorial Lecture presented at the 49th Annual Meeting of the Virginia Academy of Science, Blacksburg, May 13, 1971.

to the seventh century B.C. makes reference to the manuring of vineyards and to the "manure heap," indicating man's dependence upon animal manure at

this early date in agricultural practice.

For the livestock farmer, disposal of animal wastes has always been a nuisance, but only in the past decade has this been acknowledged as a national problem. And national problems have a way of eventually getting national attention and action. Of the four major factors that cause or aggravate the animal waste problem, the spread of urban centers into rural farming areas with the concomitant public awareness of an aesthetically pleasant environment (2) has done little to help agriculture's image.

Today the problem is still with us on a grand scale. The amount of animal waste produced by 5 million feedlot cattle, 7 million milk cows, 100 million laying hens, 50 million turkeys, 400 million broilers, 10 million hogs, and 2 million lambs on feed is the equivalent to the human waste produced by more than 200 million people. In terms of waste disposal, this is equivalent to doubling of our national popula-

tion (3).

Closely related to animal manurcs as sources of nutrients are the commercial fertilizers that have largely taken over the job of furnishing plant foods to meet ever increasing crop demands. For years, research and extension workers have stressed the use of fertilizer in balanced crop production schemes, and with time, farmers have responded to these efforts and the obvious economic pressure of per-acre

efficiency.

But again this use of agricultural technology has become a source of environmental concern. Nutrient buildup in our streams, rivers and lakes is blamed on agriculture. Many uninformed conjectures stamped a "guilty" brand on agriculture because it was the most obvious user of the nitrogen, phosphorus and other nutrient elements that were contaminating water supplies and enriching nearby bodies of water. Furthermore, nitrate accumulation in leafy vegetables has led to assertions that man-made fertilizers are health hazards and that their use should be restricted.

The basic concept of some who attack fertilizers is a rather simple one. Since nutrient enrichment and fertilizer usage have both gone up dramatically during the past 15–20 years, one must be the cause of the other. Little consideration is given to the fact that other nutrient inputs have likewise increased over the same period of time. For example, detergents have temporarily stolen the spotlight from agriculture as the prime supplier of phosphorus to our waterways. Domestic sewage, including detergents, is now known to supply the bulk of this element. As steps are taken to eliminate phosphate-based detergents, this situation will change. Agriculture will again be a prime target.

In addition to the leaching of nutrients, surface drainage and erosion of farm soils is a major source of the enrichment of waters being used for recreation and municipal supplies. Surface drainage carries off some fertilizer that has been applied to crop land. Erosion is still a serious cause of silting as well as

the loss of unprotected crop land. Some 4 billion tons of sediment are washed into our waterways each year (4). All this does not come from agricultural land, however. Denuded soils from highway construction, residential development, or strip-mining operations also make vast contributions to these problems.

Because of their proximity to agriculture—and because they are processing agricultural products—food processing plants also come under the same criticisms being leveled at farmers. The extent of the pollution problems they present depends on the nature of the processing wastes and their disposition. Food processing wastes are problems which require for their solution research and technology inputs as well as restrictive criteria and standards for pro-

cessing effluents.

Last among the major agricultural sources of environmental pollution are those activities that contribute to atmospheric contamination. Some of these are pesticide dust and sprays, but more to the point are agricultural practices that depend on burning wastes and crop residues as a means of disposal. Increasingly, agriculture is being criticized for contributing smoke and haze to an already well-laden atmosphere. Fortunately, however, the burning of cultivated crop residues is in reality a minor source of air pollution in terms of noxious contents and contribution to the total. If I may be allowed to delete forest fires from commercial agriculture sources, then agriculture contributes less than 10 percent by weight of the air pollution emissions produced in the United States (5).

In reviewing the foregoing environmental concerns, I return to my original contention in respect to the bad image of agriculture. Ten years ago this image was only partially developed. Today it has become the basis for very serious attacks on commercial agriculture. I foresee serious problems for the entire agricultural complex unless current trends can be altered by the application of knowledge and reason.

Of course, agriculture is not alone in the environmental arena and other industrics are having their problems as well. Nor can technological agriculture be singled out in what some commentators have referred to as a growing disenchantment with science and technology. I submit that flagging confidence in technology, the unrest in our cities, the increased attention to social problems, dissatisfaction with foreign policy, and the growing concern for the quality of the environment are deeply enmeshed with each other and constitute a very serious array of concerns for the American people.

Unfortunately for agriculture, we have been caught up in a groundswell of concern, and because of its subordinate, social, political and economic positions, on-the-farm agriculture is all too easy to identify as a contributor to environmental pollution. In this sense, our technology and productivity have been turned to a disadvantage. Because the American farmer has done so good a job in assuring continued plentiful food supplies, his worth to society is taken for granted, and in the public mind our bulging super-

markets are all-too-easily divorced from the basic source of that abundance.

Agriculture's Positive Contributions to Environmental Quality

In addition to furnishing nearly 55 billion dollar's worth of food and other farm commodities to our economy and social well-being (6), agriculture makes important positive contributions to the quality of our environment. Quite likely it will be called upon to take an even more active role in dissipating the wastes of our industrial society.

There are some very simple agricultural processes that assist man in maintaining a clean environment. For example, all green plants convert the CO₂ wastes from factories, automobiles, homes and directly from man himself into plant tissue releasing life-giving oxygen. Other products such as sulfur dioxide, nitrogen oxides, nitrate and ammonium salts are likewise absorbed. Add to this the scrubbing capacity of soils to bind chemicals such as fluorine, lead, arsenic and phosphorus thereby removing them from contaminated air. Even though these processes may proceed without man's guidance, they are examples of agriculture's beneficial contributions to environmental quality.

Agriculture can take justifiable pride in the long tradition of concern for the environment. Among these are schemes of crop rotation that preserve or aid soil conditions and fertility. Legume crops and the use of barnyard manures also are examples of man's efforts to replenish his basic soil resources through the protection of cover crops and increased

fertility.

We should also take note of the soil and water conservation efforts that have been underway for nearly 40 years. Again, technology and engineering have instituted strip-cropping, reforestation, controlled drainage, water impoundments, and better management practices to enhance the environment. They have provided recreation facilities and opportunities, and generally contribute to the well being of our environment—while at the same time increasing the productivity of our farms and their contribution to national abundance. Outside of agriculture, there are very few industries that have combined greater productivity with restoration of the resources they utilize or consume.

Agriculturalists as partners with landscape architects provide positive inputs into a quality environment. The culture and special placing of ornamental plants and flowers can completely transform an environmental setting. Affluent Americans have long recognized and utilized this principle. In recent years we are beginning to realize how important are plants in the center city and in the intermediate suburbs as one moves to the open countryside. Ornamentals are no longer the monopoly of the well to do. These arc beginning to be used to favorably transform the surroundings of all Americans.

Agricultural Efficiency/Environmental Pollution

It has been said that many of agriculture's woes are the direct result of its successes. This relationship between agriculture efficiency and environmental quality exemplifies this point. The prime elements of an efficient agriculture each carries with it built-in side effects that can adversely alter the environment. For example, economies of scale have favored concentrating crop and animal production into gigantic production units. These same mass production units are accompanied by concentrations of wastes which are the trouble makers. Feedlots and large food processing plants are cases in point.

Man's knowledge of the chemistry of life processes has been a second prime source of increased agricultural efficiency. Through the manipulation of critical chemicals, nature has been improved upon. At the same time some of these chemicals have side

effects which make them unacceptable.

One important point should be made here. Science and technology have been responsible to no small degree for improved agricultural efficiency. Unfortunately, however, they have made relatively less input into alleviating the side effects which adversely affect environmental quality. Even more serious is the seeming attitude of society toward science and technology. Rather than seek ways by which research can be used to solve pollution problems, there is a tendency to ignore research and to seek solutions exclusively through restriction and regulation. The proponents of this approach appear to want to turn the clock back so to speak to the days when no chemicals were used at all. While this path may have temporary political advantages, it ignores long-term socio-economic disadvantages.

Developing Solutions to Agricultural Pollution Problems

As I have indicated, the primary challenge to agriculture is to maintain the advantages of teehnology while at the same time to alleviate the problems that result from it. To be sure the task is not easy, especially in face of reduced absolute support for research in these new directions.

One of the best illustrations is found in the realm of pest control. Again, the dissociation of quality food supplies from the realities of farm production have been all too easy for the public. Despite the abundance of blemish-free fruits and vegetables that reach the market, pest control remains as a very serious problem in the United States and more espe-

cially in the remainder of the world.

Estimates of agricultural production losses due to pests in this country are as high as \$14.3 billion (7). Another \$2.3 billion is lost to pests in storage, processing and marketing activities. Important as such economic figures are, they are secondary to the Indian and Pakistani who have a more important biological problem. Millions of their countrymen are on the verge of starvation and hundreds of thousands have died from lack of food. The most optimistic demographers give some hope of bringing human population into line with food production, but the more realistic suggest that this goal is at least a generation away. In the meantime, food must be produced—the pesticides and fertilizers and new high-yielding varieties offer some hope of doing so.

The Indians and Pakistanis are unfortunate in that their primary concern must be for the immediate benefits to man from these chemicals. In their situation, man's needs must supersede those of fish and wildlife—on the basis of food production as well as human health and well being. May I then make one point abundantly clear? In my judgment, there is no reasonable alternative in this country or elsewhere. *Man must control pests* if he is to survive and if, in this country, we are to maintain our current level of living. The task then is to select means of controlling pests which are compatable with a quality environment.

A vivid example in our own country is the very real threat of another newcomer household term—Southern corn leaf blight. In just over a year's time, this pathogen of susceptible hybrid corn strains has made itself well known in the commodity markets, the feed industry, and especially in the seed corn business. Hundreds of thousands of dollars are being spent for research, monitoring, control, education, and related activities this year to head off the repetition of the losses of millions of dollars that are still being attributed to the 1970 epidemic. Such outbreaks are not rare in agriculture, but when they occur in major crops and impose a multiple effect throughout the economy, they can assume substantial proportions in a relatively short time.

The corn blight episode points to one of our most dependable and widely used biological techniques for controlling pests—the development of host resistance. The creation and improvement of pestresistant strains and hybrids of crop plants has provided scientists with a dependable tool with minimal environmental side effects. Unfortunately, the research and development input has been wholly inadequate to fully realize the potential of this technique. For example, only about 4% of the genetics research effort of the U.S. Department of Agriculture and the State experiment stations is devoted to insect control and about 12% to disease control.

Considerable progress is being made to replace the persistent chlorinated hydrocarbon pesticides. In some cases new chemicals are being developed which are more specific for the pest in question and less persistent in the environment. There is greater assurance that these chemicals will not harm nontarget organisms such as fish and wildlife. Unfortunately, some of these chemicals arc more harmful to man than some they replace. They will tend to be more expensive because of the much higher research and development costs and because of the more limited range of crop-pest situations in which they can be used. In spite of these difficulties, however, the chemical pesticide route seems to be an ecologically less rocky one than was the case even a year ago. This is well since pesticides will likely continue to be our first line of defense against pests for some time to come.

Even though chemicals are our most practical immediate means of pest control, alternatives are being developed. For example, increasing attention is being paid to the development of such biological controls as predator species, sex attractants,

chemosterilants, parasites, juvenile hormones, sterilization, and genetic resistance. These and cultural controls, repellants, genetic manipulation and more specific chemical controls have all been widely publicized as being promising new developments that need only further refinement before they will become reality.

I am not being a pessimist to suggest that many of the biological control methods are many years from practical use, if in fact they ever reach that stage. It is true that some of these hold some promise for controlling some species. Much remains to be done, and it is not a breach of secrecy to allow that all research does not result in cminently successful innovation. Agriculture has its Edsels and TFX's too.

The method of using sterile male flics to overwhelm the natural breeding population of screwworm infestations is often held as a model for the future of insect pest control. The enthusiasts, however, are not always aware that this particular method was nearly 20 years aborning, being first proposed in 1938 (8, 9). Pioneering work is nearly always laborious and it may be that recent work is accumulating knowledge applicable to other species. But these reports should be viewed with caution when they are accompanied by promises of instant and widespread success in the offing.

More likely, a combination of pest controls, used in concert, will become the most useful practice in time. Such integrated controls will probably involve all or most of the methods mentioned in one form or another. Suffice to say, we are not yet ready to abandon the useful pesticides we now have. And I would add that legislating the controls out of existence does not take the pests with them.

Progress is being made in the development of techniques to cope with other wastes and residues. For example, the utilization of oxidation ditches to literally burn wastes from hog lots is now a common procedure. Techniques to aerate and agitate water troughs containing the wastes let the microorganisms destroy the wastes with minimal odor and water pollution possibilities. Similar techniques are being tried in the poultry industry.

With respect to fertilizers, the first step is to accurately identify the contribution which agriculture makes to nutrient build up in waters and in our foods. Studies are being made to ascertain the quantities of nutrients flowing from our cultivated fields. Others measure the concentration of nitrates and other nutrients in our food and feed. Techniques for keeping these levels below acceptable health limits must be found. Timing of fertilizer applications and the breeding of varieties which do not concentrate nitrates are steps that are being taken.

What of the Future?

There are two requisites for a successful and acceptable agricultural industry of the future. *First*, it must remain efficient, thereby continuing to supply American consumers with relatively inexpensive food and fiber. We now have the world's cheapest food in terms of the portion of our paychecks which goes to purchase it. *Second*, it must reduce its share

of environmental pollution to levels acceptable by a knowledgeable society. To achieve these two objectives will likely require societal inputs far greater

than those currently being invested.

Turning first to the efficiency problem, we have customarily quoted evidence to the effect that America's agriculture is more efficient today than ever before. This evidence is expressed in terms of criteria such as output per hour of labor or the number of people being fed by one farmer, or to the tax-payer it is expressed in terms of subsidies. Unfortunately, there are other criteria of efficiency which suggest that today's agriculture is not gaining in efficiency. The Economic Research Service of the U.S. Department of Agriculture has compiled data (10) showing the following increases in agricultural output per unit of total inputs:

> 1930's 1940's 14% 1950's 25% 2% 1960's

Since 1965 a decrease in output-input ratio has been registered. Bluntly stated, our yields and animal performance are showing signs of reaching plateaus where added inputs do not bring forth the degree of response we were receiving 10 or 20 years ago. This situation is serious under any circumstances. At a time when many of agriculture's tools are being critically examined, it is even more serious.

Turning to the "environmental" side of our coin, the situation also presents serious problems. Alternates to the use of chemical pesticides and to other chemical additives require greatly increased research and development inputs from government sources. Industry cannot be expected to do research to improve techniques which will put it out of business. Furthermore, many of the alternates involve techniques which would provide industry no means of recouping its research and development investments. They involve no products which industry can sell to regain its research and development inputs. Consequently, the development of these methods must receive public support if they are to be effective. This fact does not seem to have registered fully on those who are most eager to improve the environment and to reduce environmental pollution.

It is obvious that research and education are two prime inputs needed for a sound policy respecting agriculture and environmental quality. Research must help provide bases for a two-pronged attack: (a) continued efforts to maintain and repeat the efficiency breakthroughs of the preceding decades and (b) new efforts to improve environmental qual-

Education has a multifaceted role, not the least of which is to provide the public with all the facts. Agriculture cannot lose in the long run if decisions are made on facts rather than emotion. The probability of such being the case is greatly increased if educators do their part.

It seems to me that one is led to several reasonable conclusions in evaluating agriculture's future in relation to environmental quality. Among the most significant of these conclusions are the following:

(1) The remarkable strides in American agriculture which have provided us with an abundance of wholesome food at the lowest relative costs in the world have inherent side effects which are damaging the quality of our environment. While we may differ with respect to estimates to the extent of the damages and the benefit:costs associated with them we cannot deny they are there. In service to society, it is agriculture's responsibility to determine the true extent of the damages and to help develop methods of reducing them.

(2) The drive to obtain public awareness of the problems of pollution has caused emotion and fear to replace science and facts as bases for decisions relating to agriculture and environmental quality. Efforts of all reasonable people should be devoted to the obtaining of facts and to the insistence that

decisions be based on them.

(3) Alleviation of agricultural pollution while maintaining agricultural efficiency is dependent upon new techniques which can be developed only with a marked expansion in public support for agricultural research and development. Unfortunately, the public generally and legislative bodies particularly have not recognized this fact.

(4) While awaiting the development of new and better technologies, decisions relating to restrictions and regulations of agriculture will be made. These decisions should be based insofar as possible on scientific facts and judgments. They should also be cognizant of their socioeconomic effects on the Amer-

ican public.

I am impressed with the analogy of our environmental problems and the situation faced by a fisherman in a leaky boat. The situation is described by Dr. C. P. Gratto of Iowa State as follows (11). "The fisherman has a problem with his immediate environment. If the water level gets too high the boat will sink. If the water level gets too low, he has spent all his time bailing. Either way he goes home without fish. If the fisherman maintains the water level between these two extremes, he has some time to both fish and bail."

Our objective is to somehow see that agriculture and society is able to both fish and bail.

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"What Country, Friends, Is This?" or Some Remarks on the Writer's Encounter With His Environment*

"... thou canst not stir a flower Without troubling a star."

—Francis Thompson.

"What country, friends, is this?" The question is Viola's who in *Twelfth Night* finds herself wrecked on the coast of Illyria. In the present collision of twentieth century man and Nature, it is a pertinent question to ask. As we look about us, the question obviously, on the whole, has not been critically posed, for we accept, indifferently and uncomplainingly, the wilful and witless ravaging of city and

countryside wherever we look.

Ecology, as we all know, attempts to study the relations between living things and their environments. The word stems from the Greek root for house, *oikos*. As dweller in his own home, as housekeeper, man is apparently an orderly creature; he does not foul his own nest. Very early in his historical development, he evolved orderly sanitary habits, as investigation of the earliest settlements have indicated. Freud asserts in Civilization and its Discontents that the coming of civilization corresponded directly with the repression of interest in genital and excretory activity. (Civilization is a condition of humankind resulting directly from the civis or the city; thus the civil virtues are those which indicate the appropriate respect and regard common to men living harmoniously together. Is it merely coincidence that civility wanes at the same time that interest in excretory and genital activity increases—as evidenced by the ready availability of pornography and the presence, for the first time in history, of common oaths and expletives which are either sexual or scatological?)

But man has shown himself historically, on the whole, to be orderly—at least in his own house. Where there is a widespread sense of community in a society, a similar sense of order has prevailed outside the home. But where a society is either

fragmented, disintegrating or alienated, the strains of differing values will be reflected in patterns of behavior no less than in architecture: one may instance the homogeneity of a medieval city with its cathedral close vs. the eclectic and haphazard building of a modern metropolis; Richmond, Virginia fifty years ago against Boise, Idaho today; a Breton fishing village contrasted with a Flemish factory town. The incongruity and eclectism of differing styles are thus often a result of the individualistic urge to do what one likes (in Matthew Arnold's damning phrase) at the expense of social harmony.

Individualism, the tendency to view oneself as a special being apart from one's fellow creatures, is a modern philosophical idea of origins too complicated to trace here. But one source is pertinent to our present purpose. Protestantism, as Weber and Tawney have shown, emphasized man's direct encounter with God, without priestly intervention, a relationship which in time sanctioned the exercise of individual initiative. The secularization of society made possible by the Protestant reformers eventually de-sanctified nature as well: it became possible by the end of the seventeenth century to study science without reference to theology—a dichotomy inconceivable to an early advocate of scientific thought such as Raleigh.

The study of things, not words, was of course, the foundation of empiricism, and hence of science and technology. It is not therefore accidental that the most important scientific and technological contributions, on the whole, have occurred in Protestant countries, and where no Counter-Reformation could repress the intellectual adventurer, as the Church had repressed Galileo; where a daring thinker could, as Wordsworth said of Newton, voyage

"through strange seas of thought alone."

An early Protestant version of the Joseph story in England emphasized with an innocent moralism this sentence: "And the Lord was with Joseph, and Joseph was a luckie fellow." The sentence—as Tawney points out in *Religion and the Rise of Cap*-

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italism—is deeply significant, for it assumes an extraordinary connection between piety and prosperity, the divine benison of wealth sanctioning the pious Protestant's exploitation of God's resources. The pursuit of individual prosperity or happiness became in time enshrined as a social summum bonum, a cornerstone of Whig political philosophy and a central tenet of middle-class liberalism. Today as in the last two centuries the question is asked: "May I not do what I like with my own?" So demands the millowner pouring the effluvia of his factory into sky and water, or the powerful financial institution which would destroy a landmark for the sake of an expedient building, or the developer who lays waste forest and stream for another sprawling suburb. To such men and institutions there is no higher social purpose to which they are answerable, for we still assume, as Tawney pointed out brilliantly in The Acquisitive Society, that all economic activities are equally useful. Without some sense of social responsibility, Tawney continues, "men do not become religious or wise or artistic, for religion and wisdom and art imply the acceptance of limitations. But they become powerful and rich. They inherit the earth and change the face of nature, if they do not possess their own souls; and they have that appearance of freedom which consists in the absence of obstacles"—an absence, he observes, which allows the seizing of opportunities for selfadvancement.

It is the individualistic assertion, an egocentric regard for one's own style and practice, which has sanctioned rapacity, permitted plunder, and laid waste a continent.

It was Emerson who observed that for every advance in society there is an equal regression. What supreme achievements of the age are our marvels of electronic communication! Yet hearken to the prophetic Ruskin, who over a hundred years ago remarked after the installation of the telegraph linking England to India: "To talk at a distance when you have nothing to say, though you were ever so near; to go fast from this place to that, with nothing to do at either one or the other: these are powers certainly." But are we sure that these are genuine advances? He warns in "Fors Clavigera" against the "mortal disease of plenty and afflictive affluence of good things," for ultimately there are only three material things needful: "Pure Air, Water, and Earth." "All day long," he continues in his address to the reader, you are vitiating [the air] with foul chemical exhalations, and the horrible nests, which you call towns, are little more than laboratories for the distillation into heaven of venomous smokes and smells, mixed with effluvia from decaying animal matter, and infectious miasmata from purulent disease."

For those of us who value the marvels of supersonic travel here again is Ruskin on the blessing of transportation technology:

There was a valley between Buxton and Bakewell, once upon a time, divine as the Vale of Tempe; you might have seen the Gods there morning and evening—Apollo and all the sweet Muses of light—walking in fair procession on the lawns of it, and to and fro among the pinnacles of its crags. You cared neither for gods nor crags but cash. . . You enterprised a Railroad through the valley—you blasted its rocks away, leaped thousands of tons of shale into its lovely stream. The valley is gone, and the Gods with it, and now, every fool in Buxton can be in Bakewell in half-an-hour, and every fool in Bakewell at Buxton; which you think a lucrative process of exchange—you Fools Everywhere.

Another scourge of unprincipled industrialism and folly was William Morris. Surveying the Century of Commerce as it drew to its close in a speech entitled "Hopes and Fears for Art: the Beauty of Life," Morris complained that men have been deprived of "possessions which should be common to all of us, of the green grass, and the leaves, and the waters, of the very light and air of heaven." How can one claim to care about a landscape when the deeds of the nation indicate contempt for the landscape itself? And Morris indicts the posters of advertisements who daub towns with "daily increasing hideousness" as well as London picknickers who by their refuse at Hampton Court "take special good care to let everybody know that [they] have had something to eat."

But it was the infernal factory towns with their noise and grime and stench which were most conspicuously oppressive in the nineteenth century. They were the "dark Satanic mills" of Blake's angered imagination, the belching factories which defiled "England's green and pleasant land." Here is Dickens in *Hard Times* describing a midlands city, Coketown:

It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood it was a town of unnatural red and black like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves forever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye, and vast piles of building full of windows where there was a rattling and a trembling all day long, and where the piston of the steam-engine worked up and down like the head of an elephant in melancholy madness. It contained several large streets all very like one another, and many small streets still more like one another, inhabited by people equally like one another, who all went in and out at the same hours, with the same sound, upon the same pavements, to do the same work, and to whom everyday was the same as yesterday and tomorrow, and every year the counterpart of the last and the next.

Perhaps it was such a chemically poisoned stream that Browning depicted in "Childe Harold to the Dark Tower Came"—

A sudden little river crossed my path

As unexpected as a serpent comes. No sluggish tide congenial to the glooms; This, as it frothed by, might have been a bath For the fiend's glowing hoof—to see the wrath Of its black eddy bespate with flakes and spumes.

Ruskin bitterly complained that "every river in England" had been turned "into a common sewer—so that you cannot so much as baptise an English baby but with filth, unless you hold its face out in the rain—and even that falls dirty."

the rain—and even that falls dirty."

No, "the nymphs are departed" as Eliot observed in *The Wasteland*, and that sweet Thames on which Elizabeth and Leicester sailed their gilded shell is now littered with "the testimony of summer nights":

... empty bottles, sandwich papers, Silk handkerchiefs, cardboard boxes, cigarette ends.

The nymphs are departed and

The river sweats Oil and tar.

"What country, friends, is this?" Across the waters of the Atlantic which yearly are filling with the garbage and refuse of two continents, and which slowly drain the capacity of the waters to cleanse themselves, —across the body Byron once described as a "deep and endless ocean," stood the shimmering promise of the New World.

Surveying the land we now live in three hundred and sixty-five years ago, John Smith declared that very probably Virginia had "the prerogative over the most pleasant places of Europe, Asia, Africa, or America, for large and pleasant navigable rivers: heaven and earth never agreed better to frame a place for man's habitation." "A fruitfull and delightsome land," he continued. "Such pleasant plaines, hills, and fertile valleys. . . and watered so conveniently with their sweet brookes and christall springs, as if art it selfe had devised them."

Robert Beverly nearly a century later reported that the fish swam in such abundance into brooks and fords to spawn that "it is almost impossible to ride through without treading on them," and in winter the waters were so crowded with fowl that one might sometimes kill several with a single shot. The foison and abundance of plains and woodlands were attested by all travellers into Virginia: oaks so straight that planks twenty feet tall could be hewn; cypresses three fathoms in girth about their roots; the ground so enamelled with wildflowers that it resembled an English garden in the spring. Of that country D. W. Brogan in *The American Character* reported that an ape, had he been so inclined, could have swung from tree to tree, from as far as the coast to the Mississippi River.

On the banks of that river I myself grew up. From the evidence of my own short lifetime's experience, the loss of our inheritance is hard to comprehend. But let me for a moment recount what has come to pass in twenty years in my own Mississippi river town. The vast forests on the other side of the levee, formerly the recreation of all the country-folk and townspeople, an area where we learned the birds and glimpsed the deer, is now fenced off, posted, and exclusively the property and preserve of a well-known paper company; and the fish which were so plentiful in the river forty years ago that the town boasted (in the manner of the American grasp for superlatives) "The World's Largest Inland Fishing Market"—those fish are dead: the markets have closed, and the catfish must be imported from other towns where the toxic effluvia of St. Louis and Memphis cannot reach.

"What country, friends, is this?" Here is how Sinclair Lewis through the eyes of Carol Kennicott in *Main Street* surveyed the American encounter with the Northern Middlewest—"a land of dairy herds and exquisite lakes; of new automobiles and tar paper shanties and silos like red towers. . . What is its future?" Main Street—the street which stretches from Albany to San Diego—is so familiar that we have accustomed ourselves to its ugliness. Fifty years ago, it looked like this—and still does:

It was the planlessness, the flimsy temporariness of the buildings, their faded, unpleasant colors. The street was cluttered with electriclight poles, telephone poles, gasoline pumps for motor cars, boxes of goods. Each man had built with the most valiant disregard of all the others. Between a large new 'bloek' of twostory briek shops on one side, and the firebrick Overland garage on the other side, was a onestory cottage turned into a millinery shop. The white temple of the Farmer's Bank was clbowed back by a grocery of glaring yellow brick. One store-building had a patchy galvanized iron eorniee...

She escaped from Main Street, fled home.

Further West, that city so absurdly dedicated to the Angels, Individualism, and the Automobile, and mercilessly depicted by Nathanael West and Evelyn Waugh, is glimpsed with detached irony from a limousine in Aldous Huxley's *After Many a Summer*. Los Angeles here is an America we see but to whose horror we become oblivious:

At every corner there was a drug store. . . Most of the girls as they walked along seemed to be absorbed in silent prayer; but on second thoughts he supposed that it was only gum that they were thus incessantly ruminating. Gum, not God. . . . A vast, untidy, suburban world of filling-stations and billboards, of low houses in gardens, of vacant lots and waste-paper, of occasional shops and office buildings and churches, built surprisingly enough, in the style of the Cartuja at Granada, Catholic churches like Canterbury cathedral, synagogues disguised as Hagia Sophia, Christian Science churches with pillars and pediments like banks. . .

EATS. Cocktails. Open Nites

Jumbo Malts

Do Things, Go Places with Consol Super Gas! At Beverly Pantheon Fine Funerals Are *Not* Expensive . . . Astrology, Numerology, Psychic Readings

. Science Proves that 73% of all Adults Have Halitosis

Jesus Saves Hamburgers ... Fine Liquors Turkey Sandwiches

Go to Church and Feel Good all Week

... You Too Can Have Abiding Youth With Thrill-Form Brassieres

"What country, friends, is this?" The American city of asphalt, bricks, eoncrete and plastie is a lasting monument to our collision with Nature. What noble memorials linger from a gracious past are maintained with difficulty: since 1940, we have lost 40% of our national architectural treasures. As William Morris emphasized eighty years ago, "No man who consents to the destruction or the mutilation of an ancient building has any right to pretend that he cares about art." Yet, curiously, in this very America which has stored up the plunderable and portable treasures of the world's past in vast and little-visited museums whose endowments are little more than the conscience money industry pays to culture, in this America we Americans can hardly preserve our own inheritance. Here is Morris again:

. . if we are not prepared to put up with a little inconvenience in our lifetimes for the sake of preserving a monument of art which will elevate and educate, not only ourselves, but our sons, it is vain and idle of us to talk about art—or education either. Brutality must be bred of brutality.

In England then, as in America today, houses, developments, suburbs sprang up for the convenience and profit of the developer. "What do you do with the trees on a site that is going to be built over?" asks Morris, "do you try to save them, to adapt your houses at all to them?" Our devastating and utterly wasteful suburban sprawls—developed from some clever promotion of the myth of country-living -are just now coming to be recognized as insupportable in a land where in thirty years there will be 300,000,000. Rather, as Ruskin envisioned in Sesame and Lilies, let there

be no festering and wretched suburb anywhere, but clean and busy street within, and the open country without, with a belt of beautiful garden and orchard round the walls. So that from any part of the city perfectly fresh air and grass, and sight of the horizon, might be reachable in a few minutes' walk.

What regard can we have for our communal habitations if we perceive our towns merely as functional extensions of commercial enterprise? Who in Virginia invented the ghastly appellations of Oilville and Gasburg for these communities? "The mere nomenclature of the country," observed Matthew Arnold in "Civilization in the United States," "acts upon a cultured person like the incessant pricking of pins. What people in whom the sense for beauty and fitness was quick could have invented, or could tolerate, the hideous names ending in ville, the Briggsvilles, Higginsvilles, Jacksonvilles, rife from Maine to Florida?"

We have not loved our land, as these names indicate—we have loved ourselves and we have wished to memorialize our names as builders of empire by attaching to them ungainly suffixes. We have not loved the soil, or the forest, or the streams, or the past: we have exploited them; or as Archibald Macleish in Frescoes for Mr. Rockfeller's City wrote of "The Makers Making America" (in both senses of the verb)—

They screwed her scrawny and gaunt with their seven year panics:

They bought her back on their mortgages oldwhore cheap:

They fattened their bonds at her breasts till the thin blood ran from them:

Men have forgotten how full and clear and deep The Yellowstone moved on the gravel and grass

When the land lay waiting for her westward people.

Thinking only of our own narrow self-interests, we have used and abused the land that has nourished us, pushing on when the soil failed, when the forests were thinned, when the mines were exhausted: there was always more westward, and leaving our habitats behind we littered and defiled the path to the Pacific. We ignored the quiet and tranquil gifts of Nature, "the reason and faith" which Emerson found in the woods as we ravaged the continent. Even the parks themselves have not escaped our corruption, for in the Sequoia National Park, for a quarter of a dollar, it was possible a few years ago to hear Nelson Eddy singing "Trees."

As Hopkins wrote of the corruption of commerce on our sensitivities,

Generations have trod, have trod, have trod; And all is seared with trade; bleared, smeared with toil:

And wears man's smudge and shares man's smell-the soil

Is bare now, nor can foot feel, being shod.

But new generations are coming. From the perspective of the Apollo space flights, the earth is indeed a lovely, hospitable planet bright with life in "the cold interstellar spaces"; and from the supralunary vista, we must perforce realize our interdependence. The forests and gardens we cultivate, the buildings we erect, the waste we deposit, the life-styles we profess: all must be seen to serve some greater social purpose than mere convenience or self-advancement or doing what one likes and doing what one wants to with one's own.

Surely the import of youthful protest derives largely from the raising of issues which are critical to our survival, not only as a culture but also as whole human beings. For in their questioning of rapacious economic individualism and of the value

of accumulating "things" at the expense of ignoring the needs of our fellow man, the unexamined pursuit of materialistic ends will not be as possible; and correspondingly there are signs in the back-to-nature styles and movements that other and older values may be cherished once again.

Santayana in 1894 rebelled against his generation who would heap up "to make them happy, / Many possessions." He asked of them that they examine the meaning of their striving, lest they leave another Tower of Babel which their posterity would curse:

O leave them rather friendlier gods, and fairer

Orchards and temples, and a freer bosom! What better comfort have we, or what other profit in living.

profit in living, Than to feed, sobered by the truth of Nature, Awhile upon her bounty and her beauty,

And hand her torch of gladness to the ages following after?

Against the present generation of empire builders, of aggressive strivers who forget the interdependence of flower and star, we must also rebel, that our children may sing songs of joy for what we have preserved rather than curse us for the empty inheritance of an acquisitive society.

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Comparisons of Two Antarctic Lakes with Different Trophic States

Abstract-We compared primary productivity, physical features, and chemical and biological composition of an oligotrophic and an eutrophic lake during January, 1970 at Anvers Island, Antarctica. Both lakes, less than 500 meters apart, had partial ice cover the entire season and were underlain with a similar silica-rich granite. Striking dissolved chemical differences were Cl $^-$ (7.5 and 35.0 mg/1), NH $_4$ $^+$ -N (0.1 and 2.5 mg/1), and organic C (0.97 and 6.94 mg/1), total PO₁=-P (0.03 and 1.7 mg/1) respectively for the oligotrophic and eutrophic lake. Particulate organic C was 0.031 and 0.144 mg/1. Extractable total chlorophyll ranged from 15-41 mg/m³ and 35-112 mg/m³ in the two lakes during the three week study period. Ranges in net photosynthesis were 0.78-3.5 and 9.0-72.0 mg C/m³/hr respectively in the oligotrophic and eutrophic lakes. Diel ranges for chlorophyll and carbon fixation also fell within these values. The advanced degree of eutrophication of one lake over the other apparently was induced initially by surpluses of NH₄+-N and PO₄=-P.

Introduction

Limnological information, including some identifications of fresh-water algae, in the western portion of the Antarctic Peninsula and subantarctic islands near Palmer Station have been reported by Bryant (1), Holdgate (2), Hirano (3), and Cameron (4). Adie (5) and Hooper (6) noted geological features of this area. Besides temperature and general habitat descriptions, these earlier reports of lakes and melt pools lack detailed information on physical, chemical, and biological features. This lack of information, coupled with our detection of several apparent small lakes in aerial photographs1 of the U.S. Palmer Station area, encouraged this preliminary investigation of fresh-water phytoplankton ecology on the Antarctic Peninsula. We report here a comparison of two aquatic ecosystems with different "trophic states" studied during January, 1970 at Anvers Island, off the western coast of the Antarctic Peninsula (64°46'S, 60°05'W).

Methods and Materials

This field study was specifically aimed at corre-

lating measurements of radiation, temperature, pH, various chemical "nutrient" levels, extractable chlorophyll, and photosynthetic ¹⁴C-fixation rates of phytoplankton. Studies were conducted daily from January 10-26, 1970 whenever climate and logistic support permitted.

We examined morphometric features of the lakes and measured incident radiation using a pyranometer (model 68, Yellow Springs Instrument Co.), which is sensitive to the visible spectrum and has 5% precision and \pm .01 langley/min accuracy.³ Also, we measured subsurface radiation at the depth of our experiments with the YSI pyranometer. Air and water temperatures were taken with a YSI thermistor (model 41) calibrated against a standard mercury thermometer and having \pm 0.1 C accuracy.

Analyses of dissolved chemicals were made both in field and at Palmer Station laboratory with Hach Chemical Company's model DR-EL kit and accessories, replicate samples yielding values within ± 5% of one another. Representative rock samples from the lake basins were examined by the thinsection petrographic counting technique, paying special attention to iron minerals.

Phytoplankton were identified to genus with a Nikon field and binocular phase laboratory microscope, often after necessary concentration in a Foerst continuous-flow centrifuge or with a 76 μ pore plankton net. Identifications to species require extensive study of laboratory cultures, fresh, and preserved material (7,8).

Total chlorophyll per liter of lake water was determined by acetone extraction of particulate matter retained on Millipore GS filters with 0.22 μ pores. The acetone extracts were analyzed with a B and L Spectronic 20, using the equations by SCOR /UNESCO cited by Strickland and Parsons (9) and adjusting calculated concentrations to values equivalent to 10 cm path-length tube determinations. Dissolved and particulate organic carbon were determined for us by Dr. Sayed El-Sayed, employing

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¹Published by the Directorate of Overseas Surveys, Great Britain.
² 'Tronic States'' is used here to designate significant differences in photosynthetic production by phytoplankton.

³ langley = gram calorie • cm⁻² (also, see 12).

the sensitive chemical oxidation method used in his oceanographic investigations (10). Also, we determined primary productivity by the *in situ* ¹⁴C method of Steeman-Nielsen (11), as modified by Goldman (12) and Strickland and Parsons (9). For this, we employed 250 ml screw cap pharmaceutical bottles instead of the other types of containers used in such previous primary productivity studies (9–12), as we have found these superior in their optical transmission and operational features to the other containers (Parker and Samsel, unpubl.). Values here reported for both total chlorophyll and carbon fixation are means of duplicate samples which differed from each other by less than ± 5%.

Except as indicated, data and collections are from approximately 20 cm depth in ice-free water; other methods will be cited concurrently with our data.

General Features of the Lake Basins

Both lakes are located within a 4 km radius of the new U. S. Palmer Station on Anvers Island, Antarctica. Lake no. 1 (Fig. 1), possessing the lower trophic state, had a surface area of about 3.6 km² and was located directly behind the formerly occupied United Kingdom Base at Norsel Point, Anvers Island. A resident bird population of about 60 Sterococarius skua, some of which nested at the rim of the lake basin, frequented the shallow

open water and ice-covered portion of this lake during the study period. Lake no. 2 (Fig. 2), possessing the higher trophic state, was situated on Humble Island about 500 m distant. Figures 1 and 2 show also Lake no. 1 had >90% snow and ice cover and a maximum depth of 6.2 m, while Lake no. 2 had <30% ice cover and a maximum depth of 0.6 m during our study. Fauna associated with Lake no. 2 basin also included about 60 skua, but in addition, several hundred antarctic terns (Sterna paradisaea), a few nesting giant petrels (Macronectes giganteus), and one elephant seal, the total faunal biomass being at least an order of magnitude greater than that of Lake no. 1. Also, an Adélie penguin rookery (Manchot adélie), comprising over 6,000 individuals, occupied a significant area of the granitic rocks just beyond the northwest rim of Lake no. 2 basin on Humble Island.

Both lakes over-flowed continuously during our visits as a result of rain and meltwater from glaciers and snow banks. The complexity of outflow streams and probable scepage made impossible accurate comparisons of volume gains and losses during this preliminary study. However, observations of the major overflow streams from each lake suggested that the volume of water flowing through Lake no. 1 was an order of magnitude greater than that of Lake no. 2 although on the basis of overflow per

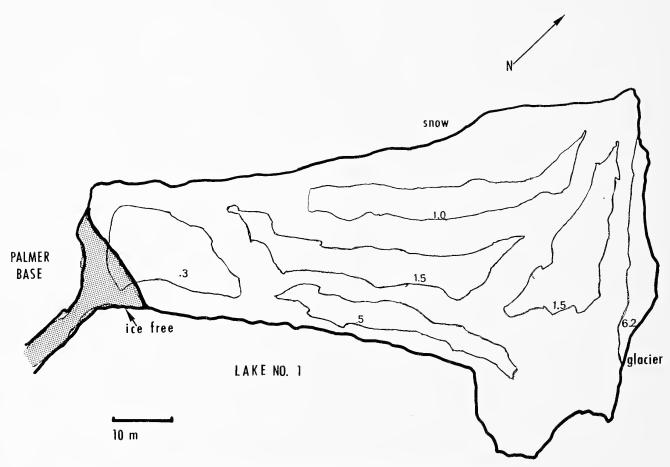


Fig. 1-Map of Lake no. 1, Norsel Point, Anvers Island, Antarctica.

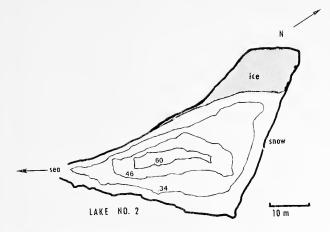


Fig. 2—Map of Lake no. 2, Humble Island, near Norsel Point, Anvers Island, Antarctica.

lake volume, the values were much closer. The apparent surface outflow rate for Lake no. 1 was about 1.0 m³/sec while Lake no. 2 had an average rate of <0.1 m³/sec. No indication of horizontal stratification based on our measurements occurred during the period of our study. Other morphometric features are presented in Fig. 1 and 2.

Much of the basin and periphery of Lake no. 2 possessed dense mats of bryophytes, Calliergidium austrostramineum C. Mull. and Polytrichum juniperinum Hedvi., also the crustose lichens, Caloplaca and Xanthoria spp. In striking contrast, Lake no. 1 lacked a luxuriant bryophyte and lichen development, with only occasional rock-inhabiting forms. Snow algae were poorly developed on the extensive snow banks which surrounded 75% of Lake no. 1, and this feature further contrasted with the frequent patches of pink snow surrounding Lake no. 2.

Results

Physical and Chemical Parameters

Both lake basins contained an igneous, intrusive, quartz-rich granite with traces of biotite and appreciable sodium plagioclase. From extensive collections of rocks in the area, there is no reason to expect the geological structure of the two lake basins to differ appreciably. As shown in Table I, the rock composition from Lake 1 and 2 basins resembles other diorites in the Anvers Island area. Notable points are the relatively small Fe⁺⁺ and no detectable chlorides, phosphates, or nitrogen components in rocks from the two lake basins.

Water temperatures ranged from -1.0 to 3.5 C in Lake no. 1 and from 1.0 to 8.0 C in Lake no. 2 throughout the three-week period of our studies. Radiation varied from levels below detection to 0.5 langley/min at approximately 20 cm depth where productivity measurements were made. At no time, however, was absolute darkness achieved. Except for two days, skies were overcast with incident surface radiation below 0.6 langley/min.

TABLE I

Elemental composition of granites of the Anvers Island area, including Lakes 1 and 2, as % of total weight

Element	Gabbro- diorite*	Quartz Diorite*	Rocks from Lakes 1 and 2 basins†
Si	24.9	31.8	25-30
Al	10.5	9.4	8-10
Fe+++	1.5	1.1	>1
Mg	3.1	0.9	2
Fe ⁺⁺	5.2	1.4	<5
Na	2.5	3.1	3
Ca	6.8	2.8	<5
K	0.8	2.0	>1
Ti	0.6	0.2	
Mn	0.2	0.1	
P	_	_	_
O	44.1	47.1	45-50
Total	100.2	99.9	

^{*} Taken from Hooper (6).

Table II summarizes physical and chemical data for both lakes; the values are representative for the entire study period during which numerous analyses were made. Note that Cl⁻, NH₄⁺-N, and total PO₄=-P concentrations show greatest dissimilarities between the two lakes, their levels being respectively 5, 25, and > 50 times higher in Lake no. 2 than in Lake no. 1.

Another striking difference between the two lakes concerns the organic matter content (Table II). Dissolved organic carbon was about 7 times greater in Lake no. 2 than in Lake no. 1, and particulate organic carbon was 4.5 times greater in Lake no. 2 than in Lake no. 1.

TABLE II

Some physical and chemical parameters of Lakes 1 and 2, (mg/1, or as indicated; values are means of at least duplicate samples, differing by less than ±5%

Parameter	Lake No. 1	Lake No. 2
pН	6.4	6.3
Turbidity	15 JTU*	63 JTU*
Dissolved O ₂	14	13
Total Alkalinity	10	12
Total Hardness	10	15
$NH_4^+ - N$	0.1)	2.5)
$NO_2^ N$	nil 🔰 1 . 1	$0.05 \ 4.30$
$NO_3^ N$	1.0)	1.75
Ortho-PO ₄ =−P	0.02	1.0
Total PO₄=-P	0.03	1.7
Cl-	7.5	35.0
SiO_2	1.0	1.5
Ca ⁺⁺	5.0	10.0
Fe ⁺⁺	0.02	0.02
SO ₄ =	4.0	6.0
Dissolved Organic C	0.97	6.94
Particulate Organic C	0.031	0.144

^{*} JTU = Jackson turbidity units.

[†] Our petrographic analysis with advice and assistance from K. Cameron, Dept. of Geology, VPISU, and Professor Roy Scharon, Dept. of Earth Sciences, Washington University, St. Louis.

Algal Genera, Chlorophyll, and Primary Productivity

As seen from Table III, only four algal genera were found in Lake no. 1, while the algal community of Lake no. 2 included nincteen genera in plankton tows and water-edge collections. Also, both lakes contained an abundance of Gram-negative-staining rods, which grew at low temperature on Difco nutrient agar plates. The bacilli cultured from Lake no. 1 represented one colony color and form, while more than 10 colony types grew from equivalent inocula from Lake no. 2. Abundant bryophyte mats, large numbers of protozoa, and a small aquatic crustacean found in Lake no. 2 were absent in Lake no. 1 collections.

Following combustion at 500 C, pale, sandy bottom sediment, from Lake no. 1, dried previously at 100 C, lost <1% of its weight, while the dark brown mud from Lake no. 2 lost 34%.

Results of one diel experiment in Table IV show that total chlorophyll content for Lake no. 1 fluctuated between 35-41 mg/m³, while that of Lake no. 2 ranged between 37-112 mg/m³. In addition to the data in this table, we made numerous daily determinations of extractable chlorophyll during the three-week field study; these values ranged from $15-41 \text{ mg/m}^3$ for Lake no. 1 and $35-112 \text{ mg/m}^3$ for Lake no. 2, with negligible variation between sample sites at 20 cm depth. Table IV also reveals that diel carbon fixation for Lake no. 1 ranged between 0.78-3.3 mg C/m³/hr in contrast to 16-72mg C/m³/hr for Lake no. 2. In addition to these data, separate daily carbon fixation rates over the three-week period range from 0.70-3.5 mg C/m³ /hr for Lake no. 1 and 9–72 mg C/m³/hr for Lake no. 2. In the diel study, (Table IV) the highest carbon uptake rate at the 20 cm depth occurred at 0940 in Lake no. 1 when the radiation reached a

TABLE III

Algal genera in Lakes 1 and 2*

Genus	Lake No. 1	Lake No. 2
Chroococcus	+	+
Aphanocapsa		+
Merisimopedia		+
Oscillatoria	+	+
Phormidium		+
Chlamydomonas	+	
Scotiella		+
Chlorella	+	+
Chlorosarcina		+
Palmellopsis		+
Dactylococcopsis		+
Ellipsoidion		+
Trachychloron		+
Trochiscia		+
Monostroma		+
Prasiola		+
Chrysococcocus		+
Chrysapsis		+
Navicula		+

^{*} Identifications of several of these algae are tentative pending further study in cultures.

TABLE IV

Diel measurements of temperature, radiation, total extractable chlorophyll, and primary productivity of open waters at 20 cm depth in Lakes 1 and 2, January 18–19, 1970

Lake	Time		Radiation langley/min)	1 2	Photosynthetic CO ₂ Fixation mg C/m ³ /hr†
No. 1	0940	3.5	0.38	37	0.78
	1340	0	0.085	41	1.7
	1800	-1.0	nil	35	1.0
	0200	0	0.12	36	1.6
	0800	0	0.18	36	3.3
No. 2	1215	7.5	0.5	112	72
	1615	4.0	0.25	56	40
	2000	2.2	0.175	37	19
	0100	4.5	0.13	45	16

* Chlorophyll values refer to first time in each interval.

maximum of 0.38 langleys/min. No consistent correlation existed between chlorophyll content and carbon fixation for either lake, nor between diurnal concentrations of sestonic chlorophyll, rate of carbon fixation, and either light intensity or temperature.

Discussion

The two lakes contrasted strikingly in several of their features. The more turbid water of Lake no. 2, containing significantly higher concentrations of phosphate (50X), total inorganic nitrogen (4X), chloride (5X), and dissolved organic matter (7X), had up to 20 times the phytoplankton primary productivity at 20 cm depth per unit area of icefree water than Lake no. 1 which was clearer throughout the study period and contained a relatively small biomass and low species diversity of plankton, including culturable bacteria, even in the ice-free shoreline areas of the lake visited by the skuas. It is unlikely that numerous species of phytoplanktonic microalgae in ice-free subsurface water of Lake no. 1 were overlooked for two reasons: (1) Our 76 μ pore-size plankton net consistently collected the four genera, two of which (Chlorella and Chlamydomonas) had cell sizes below this pore diameter; (2) the same four genera only occurred in Foerst-centrifuged water samples, a more efficient method of microalgae concentration.

Water temperature probably is not the chief factor inducing nutrient and biological differences between the two lakes, for daily temperatures fluctuated in both lakes with maximum water temperatures approaching 8 C only briefly during our studies in Lake no. 2. During periods of bright light in both lakes, water temperatures were usually highest at the bottom in shallow areas, where much of the radiant energy is absorbed and converted to sensible heat; this heat effect on the bottom no doubt contributed to some nutrient mixing, which

[†] Values for C fixation are means of duplicate light bottles less the dark bottle values; values for dark bottles and for filterable (extracellular), fixed organic matter were always <5% of the total productivity.

may have been more pronounced in the shallower, more open Lake no. 2 with significant organic matter accumulation in its sediments. Readings of radiation penetrating the expanse of snow-covered ice on most of Lake no. I were below the level of detection by our instrument (<.05 langley/min) which may have influenced the lower chlorophyll content and carbon uptake rates for this lake more than the temperature differences. A level of 0.05 langley/min, however, still constitutes several hundred foot-candles of photosynthetically usable light; consequently, a nil reading on our pyranometer does not constitute proof that no radiation penetrated the snow-ice cover of Lake no. 1. In fact, in one trial 14C experiment under the ice, we obtained a photosynthetic fixation rate of 2.0 mg C/ m³/hr. Even the higher primary productivity rates in Table IV occurred in open water at 20 cm depth in Lake no. 1 at relatively low radiation levels. This finding agrees with that of Goldman, et al. (13) who showed that radiation values above 0.2 langley/ min appeared inhibitory to both chlorophyll production and carbon uptake by antarctic fresh-water algae.

We conclude that biological production in these lakes is controlled primarily by certain nutrient factors. The data for Lake no. 1 suggest relatively small reserves of both phosphate and nitrogen. Between the two nutrients, however, phosphate would seem to be most limiting in this lake because the ratio of inorganic N/ortho-phosphate phosphorus is 55:1, while in Lake no. 2, it was 4:1. Nutrientenrichment from sea spray, as Sugawara (14) suggested for antarctic coastal lakes, does not appear to explain the differences between these two lakes, both of which have fairly equal exposure to sea breezes and do not differ markedly in their dissolved sulfate concentrations. Also, the rocky substrata of the two lakes (Table I) are so similar in mineral composition that we would not expect them to be a chief cause of the observed chemical differences of the lakes. Furthermore, mineral sources of nitrogen, phosphorus, and chloride, the

major chemical differences between Lakes 1 and

2, are absent from grantitic rocks of this area. The abundance of macrofauna and flora associated with Lake no. 2 basin suggests that at least some chemical enrichment of this lake may come from waste products in runoff although little surface runoff was observed during the period of this study. The data of Allen, et al. (15) also suggested runoff as a source of nutrients for lakes in the Cape Evans area of Antarctica. Lake no. 1 may receive nutrients from bathing skuas, but this would be relatively small when compared with that for Lake no. 2 which possessed a much greater biomass of biota in its basin. Also, we suggest that significant enrichment of Lake no. 2 may result from ammonia gas evolved from the large Adélie penguin rookery located beyond the basin rim. Uric acid is a major waste product of birds containing 33% of its weight as nitrogen and it is only slightly soluble in cold water (16). Microbial decomposition of penguin guano might produce ammonium compounds

which, as a result of the alkaline conditions, would be released from the guano into the air as gaseous ammonia. On passing in the wind over Lake no. 2 with slightly acid pH and over the extensive mats of bryophytes and lichens in the lake basin, significant amounts of this ammonia might be absorbed. This ammonia enrichment from sources outside the lake basin, coupled with phosphate additions to Lake no. 2 from sources within the basin, could promote the observed natural eutrophic features of high species diversity, high chlorophyll content, and high primary productivity. Comparatively, the 90% ice-covered Lake no. 1 some 500 meters from ammonia evolution of the nearest penguin rookery, we suggest, receives significantly less airborne ammonia. Also, the reduced biomass of fauna and flora in Lake no. 1 basin further supports the observed nutrient-poor state of this oligotrophic lake. Further investigations during the austral summer of 1971 have aimed at testing the above hypothesis.

Comparing primary productivity of these lakes with other studies in Antarctica, Lake no. 2 resembles "Alga Lake" described by Goldman, et al (13), while Lake no. 1 approaches the productivity levels reported in numerous ice-covered, melt-water ponds of the Cape Evans area of Antarctica (17). However, nutrient and extractable chlorophyll in both Lake no. 1 and no. 2 were orders of magnitude lower than those levels found by these authors for "Alga" and "Skua" Lakes in the Cape Evans area. Such order of magnitude discrepancies between carbon fixation and both chlorophyll and nutrient levels of these antarctic lakes cannot be explained on the basis of our use of different primary productivity bottles for in situ 14C measurement. While our ¹⁴C fixation values obtained consistently in 250 ml screw-cap pharmaceutical bottles generally are 25-50% higher than those obtained in the more standard 300 ml BOD bottles (Parker and Samsel, unpubl.), we have never found order-of-magnitude differences.

In summary, we have revealed for the first time a case of natural chemical eutrophication in Antarctic fresh-water lakes. The eutrophication of lake no. 2, resulting in its higher productivity, chlorophyll, and organic matter content, as well as the greater algal species numbers and biomass, apparently has been caused by enrichment with ammonia and phosphate. Resident bird populations, especially, Adélie penguins located beyond the rim of Lake no. 2 basin, probably represent the chief sources of these nutrients inducing the higher trophic state.

Acknowledgments

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Further Studies on the Effects of Benzimidazole Derivatives on Azo Dye Carcinogenesis*

Abstract—2-Ethyl-5-methylbenzimidazole must be fed during the entire azo dye feeding period (8 weeks) to be fully effective. The toxicity of the azo dye, 3'-methyl-4-dimethylaminoazobenzene, was markedly reduced by the benzimidazole. Levels of the dye over two times that normally used to induce liver tumors could be fed with the benzimidazole with near complete protection against liver neoplasia. Glycine appeared not to be a factor in azo dye carcinogenesis or benzimidazole protection. 2-Ethyl-5-chlorobenzimidazole was an effective inhibitor of the dye-induced tumors while $2-\alpha$ -hydroxybenzyl benzimidazole was ineffective.

We have reported previously that liver tumor induction by 3'-methyl-4-dimethylaminoazobenzene (3'me-DAB) could be inhibited by feeding 2,5dimethylbenzimidazole or 2-ethyl-5-methylbenzimidazole (1). This protective effect did not appear to be due to in vitro destruction of the azo dye (2). As the protective effect of benzimidazole was found to be effective during the dye feeding period but not in the post-dye feeding period during the development of the liver tumors (1), it was desirable to determine whether there was a critical period during the dye feeding time in which the benzi-Therefore, 2-ethyl-5midazole was effective. methylbenzimidazole was fed for various intervals to determine whether there was an efficacious time period for preventing formation of dye-induced liver tumors.

When azo dyes are fed the concentration of the dye increases in the liver (3) and the concentration of riboflavin decreases (4). Benzimidazoles tend to counteract the changes in concentrations of these components in the liver (1). The benzimidazoles also decrease the toxicity of the azo dye as indicated by better survival and growth (unpublished observations). It therefore seemed feasible to determine the effect of the 2-ethyl-5-methylbenzimidazole upon tumor induction and liver concentration of dye and riboflavin with increasing amounts of azo dye in the diet.

Benzimidazoles inhibit the incorporation of glycine into heme (5) and there have been reports of a glycine incorporating factor which may be inhibited by certain benzimidazoles (6). The effect of added glycine in the diet was studied to determine whether this amino acid could counteract inhibition of carcinogenesis by the benzimidazole. Other benzimidazole derivatives, the 2-ethyl-5-chloro- derivative, which is an effective inhibitor of heme synthesis (7), and the $2-\alpha$ -hydroxybenzyl derivative which is a potent antiviral agent (8), were tested as inhibitors of azo dye induced liver carcinogenesis.

Methods

Procedures were the same as in previous studies on the effects of benzimidazoles upon carcinogenesis (1). Diets were made in two halves to separate the azo dye and the oil from the benzimidazole so that there would be a minimal amount of dye destruction, and the two halves were mixed daily at the time of feeding. The complete diet had the followcomposition: 79% glucose monohydrate (Cerelose), 4% Wesson salts, 12% casein and 5% corn oil. Vitamins were added such that each kilo of complete diet contained 3 mg of thiamine hydrochloride, 7.5 mg calcium pantothenate, 2.5 mg pyridoxine, 2 mg of riboflavin and 1 g of choline chloride. Tetracycline was added to the diets at a level of 100 mg per kilogram (9). Halibut liver oil was added to the food cups every two weeks in amounts more than adequate for the animals' needs. Food and water were given ad libitum and food consumption was measured at intervals. Unless indicated, the level of 3'me-DAB was 0.064%, and in most cases the 2-ethyl-5-methylbenzimidazole was at a level of 0.25%. Other benzimidazoles were fed at equivalent molar or per cent levels. Young adult Holtzman male rats weighing approximately 200 g at the start of the experiment were housed in wire bottom, stainless steel cages in groups of three to five. Animals were weighed and examined at weekly intervals.

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For most tumor experiments the rats (15 per group) were fed the dye-containing diet for 8 weeks followed by an additional 8 weeks of a dye-free diet at which time the animals were sacrificed and the presence of tumors observed grossly and microscopically. Analytical studies were performed after 3-5 weeks of feeding with five animals per group. The animals were sacrificed, the livers removed, homogenized in water and aliquots used for the appropriate analysis. Riboflavin concentration was determined fluorometrically (10, 11). Total azo dye concentration of the liver was determined by the method of Spain and Clayton (12), Benzimidazoles were synthesized by the methods previously described (5) with 1-chloro-3,4-diaminobenzene and propionic acid for the 2-ethyl-5-chloro derivative and DL-mandelic acid with ortho-phenylenediamine for the hydroxybenzyl derivative.

Results

Effect of time of feeding benzimidazole. In order to determine whether there was any critical period when the benzimidazole derivatives were most effective during the eight weeks of dye feeding, the most active of the compounds, the 2-ethyl-5methyl derivative, was fed at different times during the eight week dye feeding period. In the first study it was found that the second four week period of administration afforded more protection than the first four weeks (Table I). In a second experiment, animals which received the benzimidazole for only the first two weeks of dye feeding developed nearly as many tumors as those getting no benzimidazole. When rats were fed the compound for the first four weeks or the first six weeks, there was marked reduction in tumors. When they received the compound for the full eight weeks there were no liver tumors. If the compound were added

TABLE I

Effect of time of feeding of 2-ethyl-5-methylbenzimidazole upon incidence of tumors resulting from feeding 3'-methyl-4-dimethylaminoazobenzene (dye fed for 8 weeks)

	Tumors / Survivors	Survivors with Tumors
	#	%
Expt. I		
No benzimidazole	9/9	100
.25% benz.*—8 weeks	0/14	0
.25% benz.—1st 4 weeks	6/8	75
.25% benz.—2nd 4 weeks	4/11	36
Expt. II		
No benzimidazole	7/7	100
.25% benz.—8 weeks	0/12	0
.25% benz.—1st 2 weeks	7/8	88
.25% benz.—1st 4 weeks	4/11	36
.25% benz.—1st 6 weeks	5/12	42
.25% benz.—last 2 weeks	8/9	89
.25% benz.—last 4 weeks	7/12	58
.25% benz.—last 6 weeks	5/13	38

^{*} benz. = 2-ethyl-5-methylbenzimidazole

TABLE II

Effect of concentration of dye in the diet in the presence of 2-ethyl-5-methylbenzimidazole on concentration of liver azo dye and riboflavin (4 weeks on diets)

	Riboflavin	Total Azo Dye	
	μg/gm	μg/gm	
.064% 3'me-DAB no benz. .064% 3'me-DAB + 0.25%	16.5	34.5	
2-et-5-me-benz. .08% 3'me-DAB + 0.25%	24.9	25.5	
2-et-5-me-benz. .10% 3'me-DAB + 0.25%	25.3	26.7	
2-et-5-me-benz. .12% 3'me-DAB + 0.25%	22.8	28.7	
2-et-5-me-benz. .15% 3'me-DAB + 0.25%	21.1	41.3	
2-et-5-me-benz.	21.7	38.3	

to the diet during the last two weeks of dye feeding, there was only a slight decrease in hepatic carcinogenesis. When they received the compound during the last four weeks there was more protection, and when they received it for the last six weeks of dye feeding there was an appreciable decrease in tumor incidence. Animals must receive the benzimidazole for four weeks or more to be effective, and maximum effect was obtained by feeding the entire eight weeks (Table I).

Higher dietary levels of azo dye. The effect of the level of azo dye in the diet upon the concentration of liver riboflavin and total azo dye in the presence of 2-ethyl-5-methylbenzimidazole was studied. It was hoped to find a level of dye which, in the presence of the benzimidazole, would give liver concentrations of these factors similar to those found in dye-fed rats which did not receive the benzimidazole. The animals were killed after four weeks on the diet. As was found previously (1), the benzimidazoles prevented the drop in riboflavin and the rise in total dye in the liver (Table II). Even when the azo dye level was increased to 0.15%, the liver riboflavin concentration was not as low as when the benzimidazole was not fed. When the dye level in the diet was over 0.12%, the total azo dye concentration in the liver was greater than when the dye was fed at 0.064% in the absence of the benzimidazole. All of the animals on the higher levels of the dye without the benzimidazoles failed to survive the four week experiment except one with 0.08% 3'me-DAB.

An experiment in which the effect of benzimidazoles on tumor development could be evaluated with increased levels of dye was performed feeding levels of dye of 0.064%, 0.08%, 0.10% and 0.12%. The animals were fed these levels of dye for eight weeks as in previous studies. It was found that as the level of dye increased there was still protection afforded by 0.25% of 2-ethyl-5-methylbenzimidazole. No tumors developed in any of these groups except 1 tumor out of 13 survivors at a level of 0.10% of the dye (Table III). Al-

Effect of 0.25% 2-ethyl-5-methylbenzimidazole on liver tumor induction by increasing levels of dietary 3'-methyl-4-dimethyl-aminoazobenzene (3'me-DAB)

3'me-DAB	Benzim- idazole	Average Food Consumption*	Survival	Tumors/ Survivors
%	%	gm/day		%
.064	0	7.8	14/15	93
.064	.25	11.1	14/15	0
.08	. 25	10.3	15/15	0
. 10	.25	10.1	13/15	8
.12	. 25	9.8	12/15	0

^{*} Average daily food consumption during dye feeding period (1st 8 weeks)

though the dye intake was more than twice as great with the 0.12% diet than at 0.064% (as measured by food consumption), the benzimidazole was still effective in reducing toxicity and tumor induction.

Added dietary glycine. The addition of 2% glycine to the diet (at expense of glucose) had no effect upon the development of liver tumors in the rats fed 3'me-DAB, and the addition of the benzimidazole inhibited tumor formation completely whether or not glycine was present. It would appear therefore that there was no relationship between benzimidazole inhibition of carcinogenesis and glycine or a glycine incorporating factor.

New benzimidazoles as antitumor agents. In the first study on the effect of 2-ethyl-5-chlorobenzimidazole it was found that this compound was somewhat more toxic than the other benzimidazoles and the level in the diet had to be decreased from 0.25% to 0.125% after four weeks. Under these conditions the compound did not appear to be as effective as the 2-ethyl-5-methyl derivative since ten of the thirteen surviving animals developed liver tumors at the conclusion of the experiment. All the

TABLE IV

Effect of 2-ethyl-5-chlorobenzimidazole and 2-α-hydroxybenzylbenzimidazole upon liver tumor induction by
3'-methyl-4-dimethylaminoazobenzene
compared to 2-ethyl-5-methylbenzimidazole

	Tumors/ Survivors	Survivors with Tumors
		%
Expt. I		
0.064% 3'me-DAB	8/9	89
0.064% + .25% 2-et-5-me-benz.	0/14	0
0.064% + .125% 2-et-5-me-benz.	3/14	21
0.064% + .125% 2-et-5-Cl-benz.	3/11	27
Expt. II		
0.064% 3'me-DAB	11/11	100
0.064% + .175% 2-et-5-me-benz.	0/12	0
0.064% + .225% OH-benzyl-benz.	. 10/10	100

animals that survived without the benzimidazole developed tumors. In a second study the level of the chloro derivative was 0.125% during the entire eight weeks of diet feeding. At this level the chloro derivative was nearly as effective as the 2-ethyl-5-methyl compound at the same concentration (Table IV). This result is similar to the effects of these two compounds on heme synthesis where they were both effective inhibitors (7).

The first experiment testing the $2-\alpha$ -hydroxybenzyl derivative indicated that this compound could not be tolerated as well as the 2-ethyl-5-methyl derivative. A second experiment, with reduced (but molar equivalent) amounts of these two compounds, indicated that the hydroxybenzyl derivative at 0.225% was not effective (Table IV) since all of the surviving animals developed liver tumors.

Discussion

It is of interest that the 2-ethyl-5-methyl- and the 2-ethyl-5-chloro- benzimidazole derivatives were equally effective in inhibiting tumor induction and in inhibiting the incorporation of glycine into heme (7). Parallelism between these systems has also been observed with other benzimidazoles (1, 5, 13). The chloro derivative does not correlate with some of the other benzimidazoles with regard to inhibition of dye destruction by liver homogenates (14) and tumor inhibition; this derivative is a poor inhibitor of the former.

An effect on glycine incorporation and a glycine incorporating factor (6) might be overcome by added glycine if the effect of the benzimidazoles were the result of simple competitive inhibition. Addition of glycine to the diet had no effect on tumor induction in the present experiments. This result might indicate that glycine incorporation with a specific factor is not involved in this carcinogenic process, that added glycine cannot overcome the inhibition, or that the amount of glycine used was inadequate. That dye destruction by liver homogenates would not involve glycine or its incorporating factor indicates another mode of action for the benzimidazoles. Additional evidence indicating another form of action is the response of virus to the benzimidazoles. Gale reports (15) a poor correlation of antiviral activity and glycine incorporation inhibition. In this study the hydroxybenzyl derivative was ineffective in inhibiting azo dye induced tumors while it was one of the more potent antiviral agents (8). Such factors as toxicity, solubility, absorption and metabolism could affect results in the intact animal.

The fact that the benzimidazole must be fed for the entire length of the dye feeding in order to be effective might indicate a role of the benzimidazole in the metabolism of the dye or the initial carcinogenic process. They are not effective after the tumor process has begun (1). Since the dye has to be fed for an appreciable period of time to produce tumors (16) it is not disturbing that the benzimidazole has to be fed a comparable time. Evidence that metabolism of the dye is altered is indicated

by the decreased toxicity of the dye in the presence of the 2-ethyl-5-methylbenzimidazole. Levels of dye which were toxic in the absence of the benzimidazole were not toxic in its presence and the benzimidazole was still effective in inhibiting the formation of liver tumors. It has been shown that the peak time for total and bound azo dye in the liver when 3'me-DAB was fed was 3 to 4 weeks (3, 12). The present experiments showed that the concentration of total azo dye in the liver could be made equal to or greater than in those animals not receiving the benzimidazole if the levels of dye in the diet were doubled and benzimidazole fed. It is possible the bound dye was not as high, although previous studies indicated that the bound and total values tended to run parallel (12). If the amount of dye in the liver can be elevated without tumors developing, it would seem to indicate an effect of the benzimidazoles on the initial (or early) carcinogenic process. Further work is needed to indicate more clearly how the benzimidazoles inhibit the carcinogenie process.

Summary

Certain benzimidazole derivatives inhibit liver tumor induction in rats fed azo dyes. The most active of these, the 2-ethyl-5-methyl-benzimidazole, must be fed for the duration of the dye feeding period to be most effective. There was no particular interval of time during the dye feeding that the benzimidazole was more effective. The benzimidazole reduced the toxicity of the azo dye (3'methyl-4-dimethylaminoazobenzene) so that high levels of the dye could be fed. When the dye concentration was increased from 0.064% (normal level fed) to 0.12% in the diet there were no liver tumors if the diet contained 0.25% 2-ethyl-5-methylbenzimidazole. Benzimidazoles have been reported to be involved in inhibition of glycine incorporation but 2% glycine added to the diet of rats fed the azo dye did not affect tumor incidence. 2-Ethyl-5-methylbenzimidazole was effective in

reducing tumor induction in the presence of added glycine indicating the mode of action of benzimidazole was not inhibition of glycine incorporation. 2-Chloro-5-methyl-benzimidazole, an active inhibitor of glycine incorporation into heme, was an effective inhibitor of azo dye careinogenesis. An active anti-viral benzimidazole, the $2-\alpha$ -hydroxybenzyl derivative, was ineffectual in reducing liver tumors produced by feeding azo dye.

Acknowledgment

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Magnetic Susceptibility of Alkali Metals

Abstract—The magnetic susceptibility of each of the alkali metals was calculated as the sum of three contributions. Two methods of including the effect of the periodic lattice potential were considered. The Thomas-Fermi atomic model was used to determine the ion core part of the total susceptibility. Generally good agreement was found between theoretical and experimental magnetic susceptibilities.

Introduction

The total magnetic susceptibility χ of a metal can be calculated as a sum of contributions of the form

$$\chi = \chi_P + \chi_D + \chi_{\rm ion} \tag{1}$$

The paramagnetic part χ_P is associated with the polarization of spin magnetic moments of the conduction electrons. The diamagnetic contribution χ_D is due to motion of the conduction electrons. The diamagnetic term χ_{ion} represents the contribution of the ion cores.

The calculation of each term in (1) will be examined in detail.

Paramagnetic Term χ_P

The paramagnetic term χ_P can be calculated from the theory of Silverstein (1). This theory is based on the use of a variational technique to determine the polarized ground state for a system of interacting electrons. The expression for χ_P obtained by Silverstein for a system of electrons with effective mass m^* and n electrons per unit volume is

$$\frac{\chi_P}{\chi_{\text{free}}} = \left[\frac{m}{m^*} - \frac{\alpha r_s}{\pi} + 3(\alpha r_s)^2 A_{\text{corr}} \right]^{-1} \tag{2}$$

where

$$\alpha = \left(\frac{4}{9\pi}\right)^{1/3}; \qquad r_s = \frac{mc^2}{h^2} \left(\frac{3}{4\pi n}\right)^{1/3}$$

and

 $\chi_{\rm free} = \frac{3n\mu^2}{2KT_F}$ is the Pauli spin susceptibility.

The parameter $A_{\rm corr}$ is associated with the correlation energy of the polarized system. Values of $A_{\rm corr}$ can be calculated by first determining the contributions $a_{LR}(q)$ and $a_{SR}(q)$ to $A_{\rm corr}$ from the long- and short-range interaction regions. The intermediate range interactions can be described by an interpolation between the two extreme cases. A numerical integration of a(q) over all momentum transfers yields $A_{\rm corr}$. It was found that $A_{\rm corr}$ was well represented by a linear function of the form

$$A_{\rm corr} = -0.0025r_s + 0.043$$

for the alkali metals.

This result allows the paramagnetic susceptibility to be expressed by the much simpler equation

$$\frac{\chi_P}{\chi_{\text{free}}} = \left[\frac{m}{m^*} - \frac{\alpha r_s}{\pi} + 3(\alpha r_s)^2 (0.043 - 0.0025 r_s) \right]^{-1}$$
(3)

Diamagnetic Term χ_D

The theory of Kjeldaas and Kohn (2) can be employed to determine χ_D . Kjeldaas and Kohn have calculated the diamagnetic susceptibility for a degenerate gas of Bloch electrons. Their procedure was to show that the effective Hamiltonian of such electrons in a magnetic field can be rigorously expressed as a power series in P of the form H = E(P) where $P = (\hbar/i)\nabla - (e/c)A$ and $E(P = \hbar K)$ is the energy of a particular band. Expanding E(P) in powers of P leads to the following series expression for χ_D :

$$\chi_D = \frac{e^2 K_0}{12\pi^2 mc^2} \left[\frac{m}{m^*} + \left\{ \frac{28}{3} \epsilon^{(4)} + 8(E^{1221} - E^{1122}) \right\} a_0^2 K_0^2 + \cdots \right]$$
(4)

In (4), a_0 is the Bohr radius for hydrogen, $K_0 = (3\pi^2 n)^{1/3}$, and

$$\epsilon^{(4)} = \frac{3}{5}E^{1111} + \frac{1}{5}(E^{1122} + E^{2211} + E^{1212} + E^{1221} + E^{1221} + E^{2112})$$

For a particular band m,

$$\begin{split} E_{m}{}^{\alpha\beta\eta\nu} &= \left(U_{m}{}^{\beta\alpha}, \frac{1}{i} \frac{\partial}{\partial x^{\beta}} U_{m}\right) \\ &- \frac{1}{2} \left(U_{m}, \frac{1}{i} \frac{\partial}{\partial x^{\alpha}} U_{m}^{\beta}\right) (U_{m}{}^{\eta}, U_{m}{}^{\nu}) \\ &- \frac{1}{4} [(U_{m}{}^{\alpha}, U_{m}{}^{\beta}) \delta^{\eta\nu} \\ &- 2 (U_{m}{}^{\alpha}, U_{m}{}^{\nu}) \delta^{\beta\nu} + (U_{m}{}^{\nu}, U_{m}{}^{\eta}) \delta^{\alpha\beta}] \end{split}$$

Where

 $U_m = U_{m0}$ is a Bloch function with K = 0,

$$U_m^{\alpha} = \sum_j U_{j0}(p_{jm}^{\alpha}/\omega_{mj})$$

$$U_{m}^{\alpha\beta} = \sum_{n \neq m} \sum_{i} U_{n0} \frac{p_{ni}^{\alpha} p_{im}^{\beta}}{\omega_{in} \omega_{nm}} - \frac{1}{2} U_{m0} \sum_{i} \frac{p_{mi}^{\alpha} p_{im}^{\beta}}{(\omega_{im})^{2}}$$
$$p_{mn}^{\alpha} = \frac{(2\pi)^{3}}{\Omega} \int_{\text{cell}} U_{m0}^{*} \frac{1}{i} \frac{\partial}{\partial y^{\alpha}} U_{n0} d\mathbf{r}$$

$$\Omega = J_{\mathrm{cell}}$$
 i $\partial_{x}{}^{lpha}$

$$\omega_{mn} = \epsilon_m - \epsilon_n$$

The parameter Ω is the volume of one crystal cell and ϵ_m is the energy of band m at K = 0.

The first term in the expansion (4) is the well known Landau-Peierls equation.

Diamagnetic Term $\chi_{\rm ion}$

The ion core contribution χ_{ion} is given by the Langevin equation

$$\chi_{\rm ion} = -\frac{e^2(z-1)n\langle r^2 \rangle}{6mc^2}$$
 (5)

The mean square radius of the electron charge distribution, $\langle r^2 \rangle$, can be estimated on the basis of the Thomas-Fermi atomic model.

Following the procedure of Gombas (3), we define

$$\langle r^2 \rangle = 4\pi \int_0^{R_i} r^4 \rho(r) dr \tag{6}$$

where

$$\rho(x) = Bz^2 \left[\frac{1}{x} \phi(x) \right]^{3/2}$$

with

$$x = \frac{z^{1/3}}{b}r, \qquad b = 0.88a_0,$$

and

$$B = \left(\frac{2me^2}{b}\right)^{3/2} (3\pi^2 h^3)^{-1}$$

The parameter R_i is the ionic radius.

Solutions of the Thomas-Fermi equation for the alkali ions have been obtained by Brudner and Borowitz (4). It was found that these solutions are well approximated by exponential functions out to the ionic radius. For all of the ions except lithium, the Thomas-Fermi function $\phi(x)$ can be represented by

$$\phi(x) = \begin{cases} 0.90e^{-0.82x} & 0 \le x \le 1\\ 0.59e^{-0.43x} & x \ge 1 \end{cases}$$
 (7)

where the empirical constants were determined by the method of least squares. The corresponding result for lithium is

$$\phi(x) = \begin{cases} 0.90e^{-0.82x} & 0 \le x \le 1\\ 0.47e^{-0.17x^2} & x \ge 1 \end{cases}$$
 (8)

values of $\langle r^2 \rangle$ were obtained from (6) with the aid of (7) and (8).

Results and Discussion

The magnetic susceptibility contributions χ_P and χ_D depend on the effective electron mass m^* . Values of m^* have been determined by Ham (5) for two cases. In the first case, the periodic lattice potential was assumed to change only the electron mass, while the Fermi surface remained spherical. In the second case, the distortion of the Fermi surface was considered.

The results of susceptibility calculations for the spherical Fermi surface case are presented in Table I. The corresponding results for the distorted Fermi surface case are given in Table II. Susceptibilities are given in units of 10^{-6} cm³/gm at 300° K. Equation (3) was employed for the paramagnetic term χ_P . Values of χ_D were calculated on the basis of the Landau-Peierls approximation except for Li. For Li, the value obtained by Kjeldaas and Kohn was used since they have shown that the Landau-Peierls approximation is not valid for this metal and that two terms in (4) must be considered. The ion core contribution χ_{ion} was obtained from equation (5). Experimental total magnetic susceptibilities were taken from Pugh and Goldman (6) for Li, from Kittel (7)

TABLE I

Metal	χ_P	χD	χ_{ion}	$\chi_{ m th}$	$\chi_{\rm exp}$
Li	1.53	-0.07	0.00	1.46	1.89
Na	0.86	-0.19	-0.01	0.66	0.70
K	0.63	-0.15	-0.03	0.45	0.53
Rb	0.58	-0.14	-0.21	0.23	0.25
Cs	0.60	-0.12	-0.55	-0.07	-0.10

TABLE II

Metal	ΧP	ΧD	X ion	χth	χexp
Li	2.16	-0.07	0.00	2.09	1.89
Na	0.86	-0.20	-0.01	0.65	0.70
K	0.70	-0.15	-0.03	0.52	0.53
Rb	0.74	-0.13	-0.21	0.40	0.25
Cs	1.15	-0.08	-0.55	0.52	-0.10

for Na, K, and Rb, and from the Handbook of Chemistry and Physics (8) for Cs.

In general, somewhat better agreement between theoretical and experimental total susceptibilities is observed for the spherical Fermi surface case.

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The Use of Principal Components Analysis in Determining Grades and Detecting Ambiguous Questions on Multiple Choice Examinations*

Abstract—This paper illustrates how the statistical method of principal components can be used in the analysis of multiple choice examination scores. It is shown that this procedure results in the detection of ambiguous questions and an increase in the variability of the test scores. Finally, the method is applied to two multiple choice examinations given to first year medical students at the Medical College of Virginia and the results are given and discussed.

Introduction

Multiple choice examinations have become increasingly popular with educators as the number of students has increased. In addition to allowing examiners to cover a wide range of material on a single examination, this type of test lends itself quite readily to computerized grading and analysis [1]. Consequently, much attention has been given to the ability of such tests to evaluate the students' knowledge of the subject matter presented in a formal course of instruction.

A frequently used method of obtaining such an evaluation is through the determination of grades. This implies that we want to distinguish among those taking the test according to their knowledge of the subject matter on which they are tested. It follows that such a distinction is more readily accomplished when the standard deviation of the students' examination scores is large. Pratt and Ingersoll [2] present a method of scoring which results in an increase in the variance of the test scores. Theirs is a subjective approach based primarily on intuition. The present paper presents a method of scoring based on a well known statistical technique which yields scores having maximum standard deviation. The effect of maximizing the variability of test scores will be discussed later.

The problem of ambiguous questions has long

been associated with multiple choice examinations. In the past, this problem has been handled by the careful selection of questions to be included on an examination. In some instances, the examinees are given the opportunity to point out questions which they feel are ambiguous and if the examiners are in agreement such questions are deleted. This or any similar procedure is seen to be advantageous in that it allows a more valid evaluation of the test results. However, in many other instances, such as the College Board Examinations, Graduate Record Examinations, etc., the examinee is not afforded such an opportunity. An objective method for detecting those questions which when correctly answered serve to cause another question to be incorrectly answered will be presented and illustrated in this paper.

Method

For each question, a student is given a score of 1 if the answer to that question is correct or a score of 0 if the answer is incorrect. The score for the test is then determined by assigning a weight to each question, multiplying each question's score by the weight assigned to it, and adding the result for all questions; i.e., the score for the test is a linear combination of the scores for each question. In order to conform to the usual methods of scoring, the weights can be scaled in such a manner that if a student answered every question correctly his score would equal the total number of questions or the questions could be assigned weights in such a manner that a student would be given a grade of 100 when when he correctly answered every question. For these two methods of scaling, the weight for each question would be respectively, 1 and 100/n, where n is the number of test questions.

If the goal is to attain a set of test scores having maximum standard deviation, it seems logical to assign weights in such a way that the variance of the

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test scores thus obtained is as large or larger than for any other weighting scheme which might be used. Such a set of weights can be obtained by the method of principal components as described in Anderson [3] as well as other texts on multivariate statistical analysis. In applying this method to the analysis of test scores, each question is considered as a variable with observed value 1 or 0 depending on whether or not the response is correct. It turns out that the desired weights are those corresponding to the first principal component of the correlation matrix of the scores for each question. Standard computer programs are available for performing a principal components analysis. See, for example, references [4] and [5].

In this paper, an ambiguous question is one for which knowledge of the correct answer is independent of knowledge of the subject matter. Note that this includes those questions for which a correct response for one is at least as likely to elicit an incorrect response as a correct response on another question. A good test will be defined as a test which does not contain any ambiguous questions. It then follows that the covariance matrix (and hence, the correlation matrix) associated with a good test is a matrix com-

posed entirely of positive elements.

In what follows, use will be made of a theorem due to Perron [6] which states that the eigenvector (set of weights) associated with the first principal component of a matrix of positive elements will consist, exclusively, of positive elements. Thus, when, as sometimes happens, negative weights are obtained through use of the method of principal components, it follows that the covariance matrix for the test was not positive and that there were ambiguous questions on the test. If negative weights occur in the principal components analysis, the questions associated with these weights are deleted and the procedure is repeated using only the questions with positive weights. In practice, this second application of the principal components analysis changes only slightly the weights associated with the questions retained after the first analysis. Thus, in general, it may be sufficient to set all negative weights equal to zero and use the positive weights from the first analysis.

Examples

The method outlined aboved was applied to a test containing 45 mathematics and statistics questions given to the 1968–1969 class of entering medical students at the Health Sciences Division of Virginia Commonwealth University. As a result, 13 negative weights were found and those questions corresponding to these weights were omitted and the method was applied to the remaining 32 questions. This second application of the method gave rise to an additional negative weight. Since this weight was close to zero (-0.01) and small compared to the other weights (mean 0.5, estimated variance 0.0091) it was felt unnecessary to delete the question corresponding to this weight and reapply the method. It should be noted that those who constructed the examination studied this question and could find no reason for considering it ambiguous.

In order to illustrate the effect of an increased standard deviation of the distribution of test scores, the grades (% correct) were calculated from the raw scores and again using the weights from the principal component analysis (PCA) for the first and last 15 students in the class. The results are presented in Table I.

Observe that, in general, when the PCA is used the higher grades increase and the lower grades decrease. This is a result of the increased standard deviation of the test scores. The standard deviations of the raw test scores and of the test scores resulting from the PCA and the method of Pratt and Ingersoll were calculated. They were 8.8 (raw test scores), 12.8 (Pratt and Ingersoll) and 37.0 (PCA). Obviously, the PCA does increase the variability of the test scores.

Another desirable feature of the weights obtained by the PCA is that the questions which are assigned the highest weights are those questions which best distinguish among the students. For the question with the highest weight, 71% of the upper half students gave the correct answer while only 32% of the lower half students correctly answered the question. The question assigned the lowest non-zero weight was such that 100% of the upper half and 97% of the lower half students gave the correct answer. The magnitude of the weights assigned to the remainder of the questions was associated, in the same manner, with the performance of the students in the upper and lower halves of the class.

Since the variability of the resulting test scores has been increased, the problem of misclassifying students on the basis of multiple choice examinations is not as critical as it once was. Notice also that the frequency of tie scores on a test will be greatly reduced and hence the problem of ranking students with the same score will not occur as often when question

TABLE I

Firs	st 15 Stude	ents	Last 15 Students		
Student	Raw Score*	PCA**	Student	Raw Score	PCA
1	80.0	91.0	113	44.4	42.7
2	77.8	87.8 .	114	42.2	33.4
3	73.3	79.6	115	42.2	41.5
4	73.3	75.4	116	42.2	40.8
5	71.1	71.2	117	42.2	31.7
6	68.9	77.3	118	40.0	24.2
7	68.9	80.0	119	40.0	26.7
8	68.9	67.9	120	40.0	29.8
9	68.9	83.3	121	37.8	34.6
10	66.7	83.9	122	37.8	33.5
11	66.7	79.1	123	37.8	36.9
12	66.7	80.6	124	37.8	20.6
13	66.7	84.8	125	37.8	27.7
14	66.7	64.2	126	35.6	18.8
15	66.7	74.4	127	33.3	36.7

^{*} The grades were based on the complete test of 45 questions.

** The grades are those which result after the 13 ambiguous questions are deleted.

weights are determined by the PCA. For a method of handling the problem of misclassifying students or the problem of ranking students with the same scores regardless of how the scores are obtained, see Carter [7].

The definition of ambiguity given in this paper is a restrictive one and it is unlikely that the test just analyzed contained thirteen questions that were truly ambiguous in the sense of the definition. This test was given in order that the class could be divided into two groups, advanced and elementary, on the basis of the results of this test. For this reason, the examination was purposely made difficult. It turned out that the test was so difficult that a large number of students guessed at the answers to most of the questions. When guessing, a random process, occurs, it is possible to have ambiguities occur by chance, that is, ambiguities which do not really exist being found. This is what appears to have occurred in this case.

A similar test consisting of 50 questions was given to the 1969–1970 entering class of medical students at the same university. Keeping in mind the results of the analysis of the test given the previous year, those who constructed the examination were more careful not to include ambiguous questions. The test was also made less difficult than the one of the previous year. When this was done, the number of questions for which the students would have to guess the answer was decreased. This would also decrease the number of chance ambiguities.

The method described in this paper was applied to the results of this test and no negative weights were found. The standard deviations of the raw test scores and of the scores resulting from the PCA were computed and they were 13.0 and 38.8 respectively. (The method of Pratt and Ingersoll was not considered here since it is known that the PCA maximizes the variability in test scores.)

That there were no questions with negative weights would seem to indicate that the problem of ambiguity on multiple choice examinations can be solved by careful test construction. Even though ambiguous questions may exist, application of the method described here will indicate such questions and remove their adverse influence on the test scores.

Summary

In this paper, an ambiguous multiple choice test question is defined. A method for simultaneously increasing the variability of multiple choice test scores and detecting ambiguous test questions is presented. This method was applied to two different tests and the results of these analyses are presented and discussed.

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Especially for Science and Mathematics Teachers

Ideas Questions Opinions

EXPERIENCES IN MATHEMATICS

Graphing—for elementary students

You try it, then have your students try it. Connect the following points:

(2, 5) to (7, 5); (1, 1) to (2, 2); (7, 8) to (7, 9);
(2, 0) to (2, 5); (5, 2) to (4, 2); (7, 0) to (7, 5);
(3, 8) to (4, 8); (2, 5) to (3, 7); (4, 0) to (4, 2);
(5, 3) to (6, 3); (5, 4) to (6, 4); (6, 7) to (6, 9);
(1, 0) to (1, 1); (4, 3) to (4, 4); (3, 4) to (3, 3);
(3, 7) to (3, 8); (5, 8) to (7, 8); (5, 0) to (5, 2);
(1, 1) to (2, 1); (3, 3) to (4, 3); (6, 3) to (6, 4);
(5, 5) to (5, 6); (5, 6) to (4, 6); (5, 4) to (5, 3);
(7, 5) to $(6, 7)$; $(4, 6)$ to $(4, 5)$; $(4, 4)$ to $(3, 4)$;
(4, 7) to (4, 8); (5, 9) to (5, 8); (6, 7) to (3, 7).

Equations—for high school students

These equations look simple but quite often incorrect solutions occur. Can your students solve them? Use the set of real numbers. Wager: At least 95% of your class, including advanced university classes, will miss at least one of these.

$$x^{2} = 4$$
 $\sqrt{x} = 4$ $\sqrt{x^{2}} = 4$ $\sqrt{4} = x$ $\sqrt{4} = x^{2}$
 $x = 4^{2}$ $\sqrt{x} = 4^{2}$ $|x| = 4$ $|4| = x$ $|x| = -4$

Enrichment—for middle and high school students

Have a pair of students use about 5 feet of string and hang a fishing sinker so that it swings freely. Start the sinker swinging. Use a stop watch or a watch with a second hand and have the students determine:

How many complete swings does it make in 10 seconds?

What happens if you increase or decrease the weight of the sinker?

What happens if you make the string shorter or longer?

Make a graph showing the relationship between the number of swings per second and the length of the string. Can you fix it so that it swings exactly 10 times in 10 seconds?

LUCIEN T. HALL Supervisor of Mathematics Richmond Public Schools Richmond, Virginia

DEMONSTRATIONS

Equilibrium

Purpose

To show the shifting of equilibrium by the addition of a common or an uncommon ion.

The results can also be used to illustrate Le Chatelier's principle.

Materials Needed

Concentrated CH₃COOH and HCl; solutions of CH₃COONa, NaCl, and NaOH; methyl orange indicator; 6 large test tubes; test tube holder; stirring rods; conductivity apparatus; 500 ml beaker.

Procedure

- A. Add a few drops of concentrated CH₃COOH to beaker containing distilled water. Immerse prongs of conductivity apparatus. Note brightness of light. Now add more acid and observe brightness.
- B. Put distilled water, concentrated CH₃COOH, and methyl orange in each of 6 test tubes. (Petri dishes placed on an overhead projector are also very effective.) While the concentration is not critical keep the solution level the same in the six test tubes. Note color of indicator after each of the following solutions has been added to the appropriate tube and thoroughly stirred.

The equation for the original solution:

$$CH_3COOH + H_2O = H_3O^+ + CH_3COO^-$$

TEST TUBE	[CH ₃ COOH]	$[\mathrm{H_3O^+}]$	[CH ₃ COO-]
 Keep as standard Add HCl (no color change) Add CH₃COONa (turns yellow) Add NaCl (no change) Add NaOH (turns yellow) Add water (no visible change—concentration of standard solution decreases) 	Increases Increases No change Decreases Decreases	Increases Decreases No change Decreases Decreases	Decreases Increases No change Increases Decreases

Note

This demonstration is planned to be used as a part of the introduction to Equilibrium. However, if the students have been exposed to hydrogen ion concentration, pH, hydrolysis, and/or buffers, these may be brought into the discussion and the hydrogen ion concentration and pH calculated.

Methyl orange	[H+]	pН
Red	10-3 - 1	0 - 3
Orange	10-4	4
Yellow	$10^{-14} - 10^{-5}$	5 14

Solubility

Purpose

To show that an "insoluble" substance can be dissolved by the addition of an ion which will cause the formation of a "more insoluble" substance.

Materials Needed

Saturated solutions of CH₃COOAg, Na₂CrO₄, NaCl, KI and Na₂S; large test tube or beaker; stirrer

Procedure

In each step add the indicated solution until precipitation is complete (be sure to use a container of sufficient size so that the experiment can be completed in the initial vessel). Calculate the concentration of Ag⁺ after each addition.

- 1. Place sufficient CH₃COOAg solution in container to be visible to all students. K_{sp} for CH₃COOAg = 2.0×10^{-3} *
- 2. Add Na₂CrO₄ solution. Ag₂CrO₄ precipitates. K_{sp} for Ag₂CrO₄ = 1.9 × 10⁻¹²
- 3. Add NaCl solution. AgCl precipitates. K_{sp} for AgCl = 1.7 \times 10⁻¹⁰
- 4. Add KI solution. AgI precipitates. K_{sp} for AgI = 8.5×10^{-17}
- 5. Add Na $_2$ S solution. Ag $_2$ S precipitates. $K_{_{8P}}$ for Ag $_2$ S = 5.5 \times 10⁻⁵¹

Answers

CH₃COOAg	4.4×10^{-2} moles/liter [Ag+]
Ag 2CrO4	1.6×10^{-4} moles/liter [Ag+]
AgCl	1.3×10^{-5} moles/liter [Ag+]
AgI	9.2×10^{-9} moles/liter [Ag+]
Ag_2S	2.2×10^{-17} moles/liter [Ag+]
	Ag+] is less—so a seemingly "in-
soluble" substance	is dissolved to form a "more
insoluble" compone	d.
soluble" substance	e is dissolved to form a "more

^{*} Solubility constants vary slightly from book to book.

Calculations

Let
$$[Ag^{+}] = X$$

1. $AgAc = Ag^{+} + Ac^{-}$
 $K_{sp} = [Ag^{+}][Ac^{-}] = 2.0 \times 10^{-3}$
 $(X)(X) = 2.0 \times 10^{-3}$
 $X^{2} = 2.0 \times 10^{-3}$
 $X = 4.4 \times 10^{-2} \text{ moles/liter}$
 $= [Ag^{+}]$
2. $Na_{2}CrO_{4} = 2Na^{+} + CrO_{4}^{-}$
 $K_{sp} = [Na^{+}]^{2}[CrO_{4}^{-}] = 1.9 \times 10^{-12}$

2.
$$Na_{2}CrO_{4} = 2Na^{+} + CrO_{4}^{-}$$

 $K_{sp} = [Na^{+}]^{2}[CrO_{4}^{-}] = 1.9 \times 10^{-12}$
 $(2X)^{2}(X) = 1.9 \times 10^{-12}$
 $4X^{3} = 1.9 \times 10^{-12}$
 $X = 7.8 \times 10^{-5} \text{ moles/liter}$
 $= [CrO_{4}^{-}]$
 $2X = 1.6 \times 10^{-4} \text{ moles/liter}$
 $= [Ag^{+}]$

3.
$$AgCl = Ag^{+} + Cl^{-}$$

 $K_{sp} = [Ag^{+}][Cl^{+}] = 1.7 \times 10^{-10}$
 $X^{2} = 1.7 \times 10^{-10}$
 $X = 1.3 \times 10^{-5}$ moles/liter
 $= [Ag^{+}]$

4.
$$AgI = Ag^{+} + I^{-}$$

 $K_{sp} = [Ag^{+}][I^{-}] = 8.5 \times 10^{-17}$
 $X^{2} = 8.5 \times 10^{-17}$
 $X = 9.2 \times 10^{-9} \text{ moles/liter}$
 $= [Ag^{+}]$

5.
$$Ag_2S = 2Ag^+ + S^-$$

 $K_{sp} = [Ag^+]^2[S^-] = 5.5 \times 10^{-51}$
 $(2X)^2(X) = 5.5 \times 10^{-51}$
 $4X^3 = 5.5 \times 10^{-51}$
 $X = 1.1 \times 10^{-17} \text{ moles/liter}$
 $= [S^-]$
 $2X = 2.2 \times 10^{-17} \text{ moles/liter}$
 $= [Ag^+]$

VIRGINIA C. ELLETT Mathematics and Science Center 2200 Mountain Road Glen Allen, Virginia 23060

Dissolving Glass in Water

Pulverize about a one cm length of five mm soft glass tubing. Transfer some of the powder to a test tube, add a little distilled water, and mix well. To the mixture add several drops of phenolphthalein solution and note the pink color. Explain this result in view of the fact that the mole ratio of the oxides in soft glass is approximately $8 \, \text{Si} 0_2 : 1.5 \, \text{Na}_2 0 : 1 \, \text{Ca} 0$.

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Communications and Reports

A Note on the Cotton Rat in Central Virginia

On September 18, 1969, Pagels trapped a female cotton rat, Sigmodon hispidus virginianus, eight and one half miles south of downtown Richmond, in Chesterfield County, Virginia. The animal contained five fetuses of 28-30 mm (crown-rump). We trapped eleven additional cotton rats at the same site later in the fall and early winter of 1969. Eight females range from a juvenile measuring 140 mm in total length to a large adult 295 mm long, (mean = 199.0) both collected on September 24. The four male cotton rats range from 161 mm to 250 mm in total length (mean = 193.0). These specimens provide a 60 mile extension to the northern range of the cotton rat in Virginia. Cotton rats were unknown in Virginia until 1940 when Patton (1) trapped a single specimen in Mecklenburg County near the North Carolina border. This specimen extended the known range of the cotton rat 60 miles from Raleigh, North Carolina (1). Later, Lewis (2) captured cotton rats in Virginia near the North Carolina border in southeastern Brunswick County.

The trapping location is an old field of three and one half acres, and is bounded by an oak-pine forest, two roads (including an apartment complex), a creek, and railroad tracks. Vegetation on the site includes a large patch of Rubus sp., encircled by stands of Poa sp. and Andropogon sp., clumps of Dactylus glomerata and Vicia sp., and several thickets of honeysuckle (Lonicera sp.). The cotton rats were caught in an area of the field that is dominated by Poa and Andropogon. At this site we have also collected short-tailed shrews, Blarina brevicauda, white-footed mice, Peromyscus leucopus, meadow voles, Microtus pennsylvanicus, house mice, Mus musculus, and a meadow jumping mouse, Zapus

hudsonius. Meadow voles were captured in many old fields in Richmond and in adjacent counties but no Sigmodon. We trapped at several locations in extreme southern Virginia within the cotton rat's earlier reported range. Adleman collected a male cotton rat in a lowlying thicket of honeysuckle along a fence row in the southeast corner of Mecklenburg County on 24 September 1970. We collected three cotton rats, all males, four miles east of Clarksville in Mecklenburg County on 28 January 1971. The one and one half acre site is isolated behind a road and enclosed by pine forest. Traps were set over most of the field, but we observed runways and caught the cotton rats only in thickets of honeysuckle and blackberry. Likewise, Wiegert and Mayenschein (3) suggested S. h. hispidus near Aiken, Georgia concentrated in ". . . very small 'islands' of habitat which may be easily missed if traps are set in single lines or widely spaced grids." In northern Brunswick County, near the town of Alberta we caught a female cotton rat on 28 January. This site is a grassy overpass to Interstate 85. We also caught *P. leucopus*, *M. pennsylvanicus*, and *M. musculus* at this site.

Cockrum (4), Jones (5) and others reported a similar northward extension of the range of S. h. texianus in the western United States, Cockrum (4) suggested that severe winters may be effective in reducing numbers of S. l. texianus and in arresting its northward movement. Even in the center of its range large fluctuations in the size of populations of Sigmodon are not uncommon (6, 7). The decline of high populations of cotton rats has been attributed to such factors as lack of shelter, food deprivation, and an apparent inability of cotton rats to withstand cold temperatures, especially when combined with the above factors (4, 6–10). Perhaps the population discussed herein is the remnant of a greater overall movement which has been temporarily checked and the number of animals and sites reduced, possibly by one or a combination of the factors mentioned above.

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VAS VISITING SCIENTISTS PROGRAM

Statistical Report for 1970–71 School Year

The speakers list was circulated in early November, 1970, to each Division Superintendent and to one upper level science teacher in all Public Secondary High Schools and all accredited Private Secondary Schools. It contained the names of 283 volunteers from 22 institutions (see following list).

In May, reply post cards were sent to all 283 volunteers asking for a report on their visits. In analyzing the data please keep in mind that no response was received from 124 of the volunteers. Most of these may be assumed to be negative replies but perhaps a few are not. These would increase the figures on each of the statistics given.

Visits were made by 52 volunteers in response to requests from high schools. The 52 volunteers made 68 visits. The basic sciences accounted for the

topics in the majority of the total visits.

The number of students reached, according to the speakers' estimates was about 2,900 in grades 8–10 and 5,500 in grades 11–12. Counties and cities whose schools were visited numbered 26. You may be proud of the breadth and depth of this influence for science in Virginia.

On behalf of the Academy, I thank each of the volunteers and the presidents of our supporting institutions. The Academy hopes to have your con-

tinued support in the 1971–72 school year.

A. M. CLARKE
Director, VAS Visiting
Scientists Program
Box 877 MCV Station
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	Speaker	
Institution	Volunteers	Visits
Averett College	2	1
Bridgewater College	2 3 1	1
Hampden-Sydney College	1	
Hollins College	6 5 2	1 2 4 0 2 3 9 3
Longwood College	5	4
Lynchburg College	2	0
Madison College	10	2
Norfolk State College	13	3
Old Dominion University	27	9
Randolph-Macon College	2	3
Randolph-Macon Woman's		
College	3 9	0
Roanoke College	9	0 5 0
Sweet Briar College	8	
University of Richmond	12	9
University of Virginia	25	7
Virginia Commonwealth		
University (Academic Div.)	12	10
Virginia Military Institute	14	2
Virginia Polytechnic Institute	82	2
Virginia Union University	6	2 2 0 0 1
Virginia Wesleyan College	6	0
Washington and Lee University		
William and Mary (College of)	15	6
	283	68

Speaker	
Volunteers	Visits
2	2
46	31
1	0
42	9
3	0
6	0
15	2
4	1
	3
	10
18	2 1 3 10 3 1
2	1
5	0
1	0 1 2 1 3 0
9	2
3	l
3	3
1	0
5	0
3	0
47	0
283	68
200	00
	Volunteers 2 46 1 42 3 6

Visits Made by Each Volunteer		Total
One	39	39
Two	11	22
Three	1	3
Four	1	4
None	107	
No Reply by Postcard	124	
	283	68

	Nu	mber o	f Sepai	rate	
				ch Visit	Total # of
One	Two	Three	Four	Unknown	Presentations
23	16	6	7	1	111

Cities and Counties Visited (Number in Parentheses indicates total if more than one.)

Charles City (5)	Hanover	Petersburg (2)
Chatham	Henrico	Richmond (11)
Chesapeake (2)	Herndon (2)	Roanoke
Chesterfield (5)	King George	Rockbridge
Clifton Forge	Lynchburg	Rockingham
Collinsville	Newport News	Saltville
Danville	Norfolk (4)	West Point (3)
Floyd	Orange (5)	Windsor
Front Royal	Powhatan (4)	

News and Notes

ROBERT BLACKWELL SMITH, JR.

Dr. Robert Blackwell Smith, Jr., president of the Medical College of Virginia from 1956 to 1968 and provost for one year died October 8, 1971. He was 55. Dr. Smith was president of MCV until the institution merged with Richmond Professional Institute to become part of Virginia Commonwealth University in 1968. At that time he was appointed provost of VCU's health sciences division, as MCV was designated.

A native of Petersburg, Virginia, Dr. Smith attended Petersburg public schools and was graduated from MCV with a B.S. degree in pharmacy in 1937. He received an M.S. degree from the University of Florida in 1938 and a Ph.D. in pharmacology from the University of Chicago in 1941. In 1966 he received an honorary LL.D. degree from

Hampden-Sydney College.

Dr. Smith was a pharmacologist with the Food and Drug Administration's pharmacology division from 1941 to 1945. He began teaching at MCV late in 1945 and was appointed professor of pharmacology in 1947.

He was assistant dean of the pharmacy school from 1945 to 1947 until he was named assistant president of MCV in 1954. Although he resigned as provost in 1969 for health reasons, Dr. Smith continued serving as professor of pharmacology until his death.

His years as president of MCV were characterized by his emphasis on developing quality full-time faculty, on graduate education and on extending the institution's building program. The MCV School of Graduate Studies was formally established in 1957. During Dr. Smith's tenure as president, six major MCV buildings were completed or begun, including the medical education building (Sanger Hall); the Clinical Center for self-care patients; a 432-bed women's dormitory, and four residence halls. In addition, the Jonah L. Larrick Student Center was dedicated.

Dr. Smith was noted widely as a pharmacologist. He was a member of the food protection committee of the National Academy of Science and National Research Council, and had served as chairman of its subcommittee on toxicology. He also had served for several years as national consultant in pharmacology to the surgeon general of the Air Force. Dr. Smith was a former chairman of the Council of Presidents of the Virginia State Institutions of Higher Learning; a past president of the Associations of Virginia Colleges and a member of a number of organizations including the Virginia Academy of Science.

Dr. Smith is survived by his wife, Mrs. Esther O. Smith; a son, Peter Blackwell Smith of Richmond; two daughters, Mrs. George Cabell Lawton III of

Powhatan and Miss Nan Smith of Richmond; and a brother, Del. W. Roy Smith of Petersburg.

FRANK PATRICK PITTS

Frank Patrick Pitts, professor emcritus of chemistry at the Mcdical College of Virginia died August 3, 1971. He was 76.

Mr. Pitts joined MCV's department of chemistry in 1928 and was named assistant dean of the School of Pharmacy in 1954. He retired in 1965.

A native of Ambler, Pa., he was graduated from Virginia Polytechnic Institute and received his master's degree in chemistry there.

During World War II, he served with the 45th General Hospital—staffed by MCV personnel—in Africa and Italy. He retired from the army as a lieutenant colonel.

Mr. Pitts was a member of the American Chemical Society, the American Institute of Chemists, the Virginia Academy of Science, the American Association for the Advancement of Science and the Virginia Pharmaccutical Association.

He is survived by his wife, Mrs. Marion Palmer Pitts; a son, Dr. Forrest W. Pitts of Charlottesville, and a daughter, Mrs. William H. Rowan of Alexandria.

JACOBUS MARINUS LODEWIJKS

Word has been received of the death of Dr. Jacobus Marinus Lodewijks, 60, on June 21, 1971, in The Hague, Holland. Dr. Lodewijks was former president of the World Aquarium Society, a nature photographer of distinction, and at the time of his death, a member of the staff of the University of Leiden. In 1957-58 he was exchange professor of Biology at Longwood College, Farmville, Virginia.

DONALD W. DAVIS

A memorial bronze bas-relief of Donald W. Davis, fifth President of the Virginia Academy of Science (1927–28) was placed in the new Life Sciences Building of the College of William and Mary in April, 1970. Dr. Davis, who died in 1950, was one of the founding members of the Academy. The bas-relief depicts significant associations of Dr. Davis with William and Mary and with the Virginia Institute of Marine Science, surrounding his raised figure.

VEPCO ENVIRONMENTAL OPERATIONS

Dr. Morris L. Brehmer, formerly assistant director of the Virginia Institute of Marine Science (VIMS), joined Virginia Electric and Power Company November 1 as director of environmental operations.

"We feel extremely gratified to have a man of Dr. Brehmer's caliber join our environmental control department," J. D. Ristroph, executive director of

environmental control for Vepco, said. "With our massive construction program and plans to spend about \$133 million on environmental control from 1971 through 1975, we need highly qualified people to help us meet our environmental responsibilities."

Dr. Brehmer has been assistant director and head of the Division of Applied Marine Science and Ocean Engineering at VIMS since 1967. He was acting head of the Department of Marine Resource Services since 1969. From 1959 to 1967, he was head of the ecology-pollution department. He received a B.S. degree in 1950 from Eastern Illinois University and M.S. and Ph.D. degrees in 1956 and 1958 from Michigan State University in the field of pollution biology. A native of Strasburg, Ill., Dr. Brehmer was a biologist with the State of Illinois from 1951 to 1955 and was assigned to the Sanitary Water Board in 1952–53. He was a biologist with the Institute of Paper Chemistry in Appleton, Wis., in 1955. He has served as a consultant for Enviro Control, Inc., of Washington, D.C., and for the Celanese Corp. in New York. He is a member of the American Society of Limnology and Oceanography, the International Association of Theoretical and Applied Limnology and the Atlantic Estuarine Research Society. Dr. Brehmer has authored or co-authored many papers which deal with the ecology of Virginia rivers.

VIMS STAFF CHANGES

Dr. William J. Hargis, director of VIMS, has announced the promotion of Dr. Michael E. Bender to fill the vacancy created by the resignation of Dr. Morris L. Brehmer. Dr. Bender holds an M.S. degree from Michigan State University and a Ph.D. from Rutgers University. He joined the marine laboratory staff in September 1970 and has served as chairman of the department of ecology-pollution. In his new position as assistant director Dr. Bender also will be responsible for establishing a new marine resources management department.

Dr. Edwin B. Joseph formerly assistant director of biological and marine science and ocean engineering has resigned to become director of a new marine

laboratory in South Carolina.

LYNCHBURG COLLEGE GRANT FOR ENVIRONMENTAL STUDIES

Lynchburg College has received a commitment of \$15,000 from the W. K. Kellogg Foundation of Battle Creek, Mich., under the College Resources for Environmental Studies Program for the support

of projects relating to the environment.

Under this grant the college will improve its instruction in environmental studies through the development of College Lake as an instructional laboratory. The two project years will end Aug. 31, 1972 and Aug. 31, 1973. The grant is in addition to an earlier one of \$5,000 from the W. K. Kellogg Foundation for resource materials. It is one of approximately 25 similar grants made to small private liberal arts colleges throughout the United States as part of the Kellogg Foundation's continuing concern to find solutions to the Nation's environmental problems.

Dr. Gwynn W. Ramsey, professor of biology and chairman of the department, will serve as the project director and also as chairman of a review panel, which will include four other members. These are Dr. John M. Turner, vice-president for academic affairs and dean of the College; Dr. John G. Mahan, professor of biology and chairman of the division of life sciences, Samuel J. R. Gamble, associate professor of chemistry, and Dr. Charles J. Hansrote, Jr., professor of chemistry and acting chairman of the department.

The 214-acre campus has a lake with a surface area of about 15 acres. A study of the lake will be made in terms of the nature of the factors causing pollution and siltation, utilizing field courses of the biology department as an organizational framework

to gather data and draw conclusions.

BLANDY EXPERIMENTAL FARM

Tucked away in Clarke County behind a stand of trees and some hills is a 700-acre farm owned by the University of Virginia. Many Virginians and even local residents have never heard of The Blandy Experimental Farm—but they may soon. Plans are being made to revitalize the facility which is located in the northern end of the Shenandoah Valley where George Washington did much of the

original surveying.

"The University has an unusual opportunity to develop Blandy Farm into a valuable educational resource. Students today are interested in their environment and what's happening to it and Blandy Farm could provide the setting for much of the study," says Dr. B. F. D. Runk, Samuel Miller Professor of Experimental Agriculture and Forestry. Dr. Runk is the man at the University responsible for the opcration of Blandy Farm.

For several summers Arlington County students have used the farm for ecology studies. During one summer some 1,600 high school students camped out on the grounds of the farm for short periods of

time.

Also in the past year, landscape architecture students from the University of Virginia began taking field trips to the farm to study a variety of plant materials for their work.

Willed to the University in 1926 by Graham F. Blandy, the farm was to be devoted to experimental agriculture and to the teaching of young people. For

many years it was.

Dr. Orland E. White, the first director, planted an arboretum on 100 acres and established an advanced program in genetics and cyto-taxonomy for graduate students. His successor, Dr. Ralph Singleton, continued the emphasis on research and established a radiation field so that irradiation effects on corn and other plants could be studied. Students from several dozen foreign countries lived and worked at Blandy learning the techniques and applications of irradiation.

When Dr. Singleton retired as director in 1965, the radiation field was closed, graduate students left and the farm shifted into neutral. The status quo was

maintained, but no new research projects were started.

Some 600 acres of the farm are commercially farmed. On the remaining 100 stand the main building and dormitory (known as the Quarters), the greenhouses, research fields, nurseries and the arboretum

Now after six years of relative inactivity, The Blandy Experimental Farm and Orland E. White Arboretum are being revitalized. The facilities of the Quarters are being repaired and refurbished. It contains offices, laboratories and accommodations for graduate students. Its library, whose holdings are catalogued in Alderman Library at the University, contains reference books and current periodicals. New personnel are also being sought to direct research and care for Blandy's outstanding feature—the Orland E. White Arboretum.

Some 5,000 species of evergreens, hardwoods, dwarf specimens and even a variety of weeping trees such as weeping birch and spruce are represented in the arboretum, which is sometimes defined as a living museum of woody plants. Several especially large collections are well-known—the pines and firs, the oaks and the boxwoods.

Other rare or unusual plants include hollies with black berries, hybrid oaks which are evergreen, the parasol pine from Japan, the Chinese tulip tree and the ginkos, which have remained unchanged since the days of the dinosaurs.

Now mature and fully developed, it is the only such arboretum between Washington, D.C. and Miami, Florida.

"The arboretum is a valuable teaching resource for landscape architects—in one spot students can view specimens of rare or unusual trees and those which are not native to this area as well as a great variety of mature trees. The latter is very important because some trees completely change their shape and character as they mature," says Meade Palmer, lecturer in landscape architecture at the University School of Architecture. "I think the arboretum could interest many other groups as well—especially garden clubs and scout troops. I hope someday it will have paths, maps and be open to the public."

Future plans for Blandy are not yet complete, but research possibilities include ecoperating with the Experimental Fruit Station in Winchester, providing living material for cellular studies, acting as a hybridization or disease lab, as well as offering an environment for ecological studies.

NSF SUMMER STUDENT PROGRAM IN ELECTRICAL SCIENCE

Twenty-six high school students spent a major part of their summer vacation at the University of Virginia learning about the fields of electrical science and electronics engineering. The students, juniors and seniors in high schools from 14 states and one foreign country, were enrolled in an eight-week National Science Foundation secondary training program in electrical science and electronics engineering which ended August 7. For the first six weeks, the students divided their time between the lecture room

and the laboratory where members of the University School of Engineering and Applied Science's electrical engineering department introduced them to the basic theory and practical aspects of electronics engineering as well as the laboratory approach to problem solving. The remainder of the program was spent at the U. S. Army Electronic Command at Ft. Monmouth, N. J. There each student worked with a scientist or engineer on a specific problem related to the student's capabilities and interests. While at the University, students had an opportunity to learn about computer use and to visit ongoing research projects in the engineering school. Dr. E. C. Stevenson, professor of electrical engineering, was program director.

ANIMALS IN SCHOOL SCIENCE PROJECTS

The Science Subcommittee of the American Humane Association after careful study of existing guidelines dealing with use of animals in school science projects has developed its own "Guidelines," which have now been adopted by the Board of Directors of A. H. A. and thereby becomes the policy of that organization.

One recommendation of the A.H.A. Guidelines deserves special comment. This is the supervision affidavit which compels the student to have adequate supervision, as well as a written outline of the experiment he proposes to undertake if it involves living vertebrate animals.

Copies of the text of the A.H.A. Guidelines and the Supervisor's Affidavit suitable for distribution to Science Clubs and secondary schools are available on request from The American Humane Association, P. O. Box 1266, Denver, Colorado 80201.

COMPUTER TERMINAL AT MCV SPEEDS INFORMATION RETRIEVAL

A new computer terminal recently installed in the Medical College of Virginia library now links requests for fast retrieval of information in the field of medicine with the central computer facility at the State University of New York (SUNY), making readily available a resource of more than 1,300,000 citations to books and journal articles. The computer terminal at MCV, Health Sciences Division of Virginia Commonwealth University, is the 22nd such terminal now in operation connecting medical libraries in the eastern United States to the SUNY Biomedical Communication Network headquarters at Syracuse, N. Y., via telephone lines.

The computer terminal is the latest acquisition of the Virginia Medical Information Service (VAMIS). Funded by the Virginia Regional Medical Program, VAMIS was formed in 1969 by combining the resources of the biomedical libraries at MCV and at the University of Virginia. It is the first state-wide network for the exchange of medical information, and its operation makes the library resources of the two state medical schools available to the entire Virginia medical community.

Before the computer terminal was installed, a physician's request to VAMIS for a listing of medical literature on a specific subject could take two weeks

to a month of searching by hand. With the computer, the most recent citation is available in a matter of hours, according to Mr. Richard Miller, director of the MCV library. Another benefit is the ability of the computer to conduct a multiple concept search, such as a request for recent articles on the body's reaction to implant devices. It also allows VAMIS personnel to process a number of individual searches at one time—with requests ranging from information on gangrene of the foot to methods and statistics on population control in problem areas of the world.

MCV LIBRARY CONSTRUCTION BEGUN

A \$2 million construction project to modernize and expand the Tompkins-McCaw Library at the Medical College of Virginia, Health Sciences Division of Virginia Commonwealth University, is underway. It will be financed partially from state

funds and partially from federal funds.

MCV/VCU was awarded last year a \$1,294,720 federal grant from the Department of Health, Education and Welfare for modernization of the present 38-year-old library and for construction of an addition that will more than triple the existing library size. The library's current 14,500 square feet will increase to 52,000 square feet when construction is completed in 1973.

The present Colonial architecture will be continued for the new three-story library addition which will have two floors above ground and one below. The present library houses more than 100,000 bound volumes and more than 2,000 journals as well as historical interest material on MCV and a small museum collection of medical instruments and Civil War memorabilia. The new addition is expected to house the MCV archives.

BIOPHYSICS

The Department of Biophysics at the Medical College of Virginia has been awarded a \$25,000 grant from the Xerox Corporation for support of research and graduate education. The funds will aid the department's graduate program in studies of the effects of optical sources on the human eyc with emphasis on ocular safety. The grant also will aid other areas of biophysics research at MCV, the Health Sciences Division of Virginia Commonwealth University. The Department of Biophysics, nationally noted for its research on the biological effects of electromagnetic radiation on the eyc, also is involved in studies on the basic mechanisms of the photochemistry of vision, environmental hazards, and the short and long-term biological effects of microwaves, lasers, infrared and ultraviolet sources on the eye.

Headed by Dr. William T. Ham Jr., the Department of Biophysics currently is seeking further industrial support for its program in graduate education and ocular research. There are eight students presently enrolled in the doctoral degree program

in biophysics.

POULTRY SCIENCE ASSOCIATION

Paul B. Siegel, professor of poultry science at Virginia Tech, and a past president of the Virginia Academy of Science, has been elected first vice-president of the Poultry Science Association, an organization of industry and academic individuals involved in poultry research and extension.

The election took place at the association's an-

nual meeting at Fayetteville, Ark.

WATER

Water, one of our most precious and abused resources, gets the full treatment in the new Water Encyclopedia, recently published by Water Information Center, Inc. The book marks the first time so much hard-to-find and scattered information is available in one volume.

An entire chapter is devoted to Water Quality and Pollution Control, of prime concern today, with such sub-classifications as: Drinking Water Quality Standards, Industrial Water Quality, Irrigation Water Quality, Water Quality, Water Aquatic Life, Recreational Water Quality, Water Treatment Processes, Waterborne Diseases, to name just a few.

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Conversion Factors.

More than 200,000 facts qualify The Water Encyclopedia as a singular and basic reference on the subject for those in the field or just interested in it.

The 7" × 10", 550-page, hard-cover volume is available for \$27.50 from Water Information Center Inc., Dept. 3P, Water Research Building, Manhasset Isle, Port Washington, L. I., N.Y. 11050.

ENVIRONMENTAL REPORTER

"Laboratories are the first line of defense against environmental pollution." This is the thesis of the Environmental Reporter, a new magazine published

by Fisher Scientific Company.

The first edition of the *Environmental Reporter* provides information on a wide range of instruments and methods for detecting and measuring pollutants in air, water, and other substances. One article of interest to the environmental scientist gives details on a new Jarrell-Ash Vapor Analyzer Kit for high sensitivity atomic absorption determination of mercury, arsenic, and selenium using the "cold vapor" technique.

Input for the magazine will come in part from experts at Fisher Research Laboratories (FRL) and Fisher Development and Applications Laboratories. The staff of FRL in particular is working closely with the Commercial Testing Laboratory, Fisher Jarrell-Ash Division on a number of important and fundamental environmental problems. Pertinent data obtained from this commercial facility will be reviewed in subsequent issues of the *Environ*-

mental Reporter.

General Notice To Contributors

The Virginia Journal of Science heartily welcomes for consideration original articles of technical or general interest on all phases of mathematics, the natural, physical and engineering sciences. Submission of an article for publication implies that the article has not been published elsewhere while un-

der consideration by the Journal.

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Illustrations should be supplied in a form suitable for the printer with attention to the fact that a reduc-

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A good technical article generally contains an obligatory abstract before the text, an introduction, with reference to preliminary publications that may exist, an experimental section, results (which may be included in the experimental section), a discus-

sion, and conclusion. References are indicated in the body of the article by consecutively used numbers in parentheses. Although publication costs are high, attention should be given to relatively complete references (bibliographies) since the purpose of an article is to illuminate the significance of present and past findings, and not merely to obscure the past. The Journal reserves the right (generally exercised) to make page charges for articles in excess of 5 pages and to bill authors at cost for unusually complicated illustrative material.

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- 3. Riley, G. A., and Haynes, R. C., Jr., *J. biol. Chem.*, **238**, 1563 (1963).

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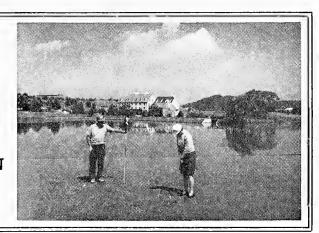
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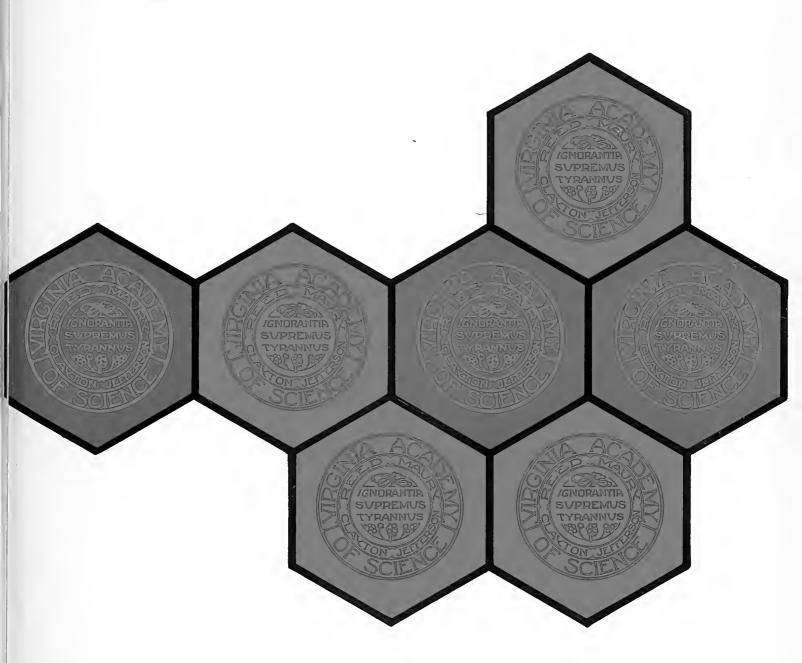
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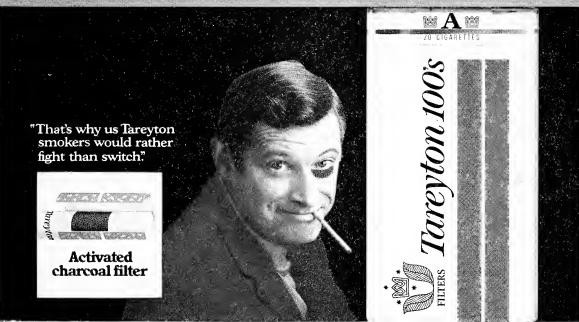
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The front cover is by Douglas C. Hensley.

Paul A. Sandifer

Virginia Institute of Marine Science Gloucester Point, Virginia 23062 Received September 3, 1971

Effects of Diet on Larval Development of Thor Floridanus (Decapoda, Caridea) in the Laboratory*

Abstract—Thor floridanus larvae maintained in laboratory culture at 24-26C and 31% salinity were subjected to four diets: a) no food, b) algae (approximately halfand-half mixture of Monochrysis lutheri and Phaeodactylum tricorntum), c) live Artemia nauplii, and d) mixed diet (diets b and c together). Twenty-seven newly hatched larvae received each diet. None of the starved larvae molted and all died within nine days. Of those larvae fed only algae, 22% survived through metamorphosis to postlarvae, whereas only 4% of those fed only Artemia nauplii survived through metamorphosis. More of the larvae which were fed the mixed diet survived to the postlarval stage than was recorded with any other diet; 48% completed metamorphosis. Development of algae-fed larvae was significantly slower than that of larvae fed the mixed diet, and there also appeared to be a slight (but non-significant) trend for algae-fed larvae to pass through more molts prior to metamorphosis than did those larvae fed the mixed diet. These results are discussed in relation to the results of other studies concerning the dietary requirements of caridean shrimp larvae.

Introduction

Live Artemia nauplii have become so widely aecepted as food for decapod larvae in laboratory culture that diet, as a factor influencing survival and development of larvae, has been largely ignored. Three important exceptions are the experiments of Broad (1) eoneerning the effects of different diets on larval development of Palaemonetes (Caridea, Palaemonidae), Chamberlain's (2, 3) studies of effects of diet on larvae of four erabs (Braehyura, Xanthidae), and Regnault's (4) recent qualitative and quantitative analysis of the effects of diet on larval development of Hippolyte inermis (Caridea, Hippolytidae). The objective of the present study was to examine grossly the reponses of larval Thor floridanus Kingsley (Caridea, Hippolytidae) to qualitatively different diets.

Broad (5) described eight zoeal stages and a postlarval stage in the complete larval development of T. floridanus reared in the laboratory. He reared the larvae with four different algal diets, but he had too few larvae to attempt culture with animal tissue as food. Dobkin (6) discovered that two species, one with the long larval development described by Broad (5) and the other with an abbreviated larval development, had been eonfused as the same species in Florida waters. He suggested that the form with long larval life be considered as Thor floridauus and the form with abbreviated development as *Thor* sp. until the necessary taxonomie review eould be accomplished to establish their correct status. In the present study, T. floridanus refers to the form with long larval life.

Methods and Materials

An ovigerous female T. floridanus was collected at Beaufort, N. C., on 17 August 1970. Salinity at the eollection site was 31.5%. The shrimp was transported to the Virginia Institute of Marine Seienee and was kept, but not fed, in a glass bowl of seawater (31%). The larvae hatched during the night of 20-21 August 1970 and were placed in the experimental situations during the following morning.

T. floridanus larvae were placed singly in small plastie vials containing 15 ml of seawater (31%). The vials were then placed individually in compartments of plastie boxes, and the boxes were set in a water bath maintained at 24-26C. Twenty-seven larvae were exposed to each of the following four diets: a) no food, b) algae (approximately half-and half mixture of Monochrysis hitheri and Phaeodactylum tricornutumi), e) live Artemia nauplii (California Brine Shrimp, Ine., Menlo Park, California) hatehed in seawater, and d) mixed diet (diets b and e together). Larvae were fed fixed amounts of eoneentrated algae and/or Artemia nauplii as appropriate. The quantitative eomposition of each diet was not determined, but the amounts given always provided an abundance of food organisms. In the ease of the algae, the eoneentration given was always such as to eolor the water slightly. There was little noticeable mortality (other than the predation by T. floridanus larvae) among the Artemia nauplii in the two diets containing nauplii. Fresh nauplii were hatehed daily for the diets, and in both cases most nauplii survived the 24 hour period during which they were presented as food to the T. floridanus larvae. No attempt was made to control the growth of bacteria in the culture water or to determine the extent, if any, of the contribution of baeteria to the nutrition of T. floridanus larvae.

^{*}Contribution No. 421 from the Virginia Institute of Marine Science, Gloucester Point, Virginia 23062
†This study was supported in part by the Virginia Institute of Marine Science's Sea Grant Program, under contract GH67, which is maintained by the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce.

Evidence of deaths and ecdyses among the larvae was sought by examining each vial under a binocular dissecting microscope once daily. Afterwards, the larvae were transferred to clean vials and fed where appropriate.

Results

The results, although quite limited because of the small number of experimental animals which were available, show several features of interest with regard to the nutritional requirements of T. floridanus larvae. Both algal cells and Artemia nauplii were ingested. The number of shrimp that completed larval development, and the number of molts and days required to reach the post-larval stage, varies with the diet (Tables I, II). None of the starved larvae molted and all had died by the ninth day, so the "no food" series was excuded from the tabulations. One to several larvae in each of the other dict series survived through metamorphosis. Lowest survival (4%) occurred among Artemia-fed larvae, intermediate survival (22%) among algae-fed larvae, and highest survival (48%) among larvae fed the mixed diet (Table I). Both the algae and the Artemia nauplii contributed nourishment to the

In the present study larval development was completed in 14 to 29 days (Table I). Broad (5) reported that *T. floridanus* larvae molted once about every two days, and development through metamorphosis required approximately 16 days in his study.

The rate of larval development was influenced by diet. Comparison of the means and ranges of days required by *T. floridanus* to reach the postlarval stage (Table I) indicates that development of algaefed larvae was slower than that of larvae fed the mixed diet. This difference was shown to be significant at the 1% level with a Student's *t* test (12) (t = 4.49, df = 17). The retardation in the rate of development of algae-fed larvae did not become evident until the fifth molt (Table II). The first four larval molts occurred at approximately the same time for algae-fed larvae, for *Artemia*-fed larvae, and for larvae fed the mixed diet. Survival of *Artemia*-fed larvace through metamorphosis was too low to allow a comparison of total time for development. However, beginning with the fifth molt de-

TABLE I

Comparison of survival and development of Thor floridams
larvae reared in the laboratory with different diets

			Diet	
		Artemia	Algae	Mixed
Initial no. of larvae		27	27	27
Survival to postlarva	(No.)	1	6	13
•	(%)*	4	22	48
Molts to postlarva	(Mean)	9	7.7	7.2
·	(Range)	_	6-10	6-8
Days to postlarva	(Mean)	21	22.3	16.3
	(Range)	_	18-29	14-22

^{*} expressed as nearest whole percent

velopment time of the *Artemia*-fed larvae appeared intermediate between that of the algae-fed larvae and those fed the mixed diet. It is perhaps at this time that animal tissue, or simply larger food particles, become important to the nutrition of *T. floridanus* larvae.

Broad (5) reported that metamorphosis of T. floridanus larvae occurred at the eighth molt. However, in the present study some larvae were observed to metamorphose at the sixth, seventh, eighth, ninth, and tenth molts, but most often at the seventh or eighth (Table II). There also appeared to be a slight trend for algae-fcd larvae to pass through more molts prior to metamorphosis than did larvae fed the mixed diet (Tables I, II). However, a modified t test (12) showed no significant difference between the mean numbers of molts of algae-fed larvae and larvae fed the mixed diet (t' = 0.78, 5% level = 2.54).

Discussion

Most studies of the effects of diet on larval development of decapods, like the present, have been concerned only with qualitatively different diets. Only a few investigators have made any attempt to measure the quantitative composition of one or more of their diets (4, 11). The others apparently followed the general methodology utilized in the present study.

Among decapod larvae which have been cultured in the laboratory to date, only those of Thor floridanus (5, present study) and Hippolyte inermis (4) have been successfully reared to postlarvae on diets consisting only of algae. Broad (5) found Nanochloris sp. and Nitzchia closterium to be adequate food for T. floridanus larvae, but the larvae derived less nourishment from Thorocomonas sp. and little or none from Chlamydomonas sp. In the present study a mixture of Monochrysis lutheri and Phaeodactylum tricornutum was found to provide adequate nourishment for T. floridanus larvac. Regnault (4) found that of six uni-algal diets prescribed (Dunaliella bioculata, Monochrysis lutheri, Phaeodactylum tricornutum, Platymonas sp., Skeletonema costatum, and Chaetoceros costatus) only Dunaliella, Monochrysis, and Phaeodactylum had any nutritive value for H. inermis larvae, and of these only Monochrysis provided sufficient nourishment to allow survival of a few animals through metamorphosis.

Most larval decapods tested to date appear to require animal tissue in their diets and are able to derive little, if any, nutritive value from algae (1–4, 7–10). As a rule, survival is highest and development most rapid among larvae fed only animal tissue (usually *Artemia* nauplii). However, mixed diets of plant and animal material also may provide adequate nourishment for decapod larvae, but such diets generally result in decreased survival and retarded development (1–4) and may cause additional instars (1). Broad (1) suggested that algae were nutritionally inert as far as most decapod larvae were concerned, and that ingestion of algae restricted a larva's intake of *Artemia* nauplii. He then hypothesized that

TABLE II

Comparison of survival and molting of Thor floridanus larvae reared in the laboratory with different diets (initially 27 first-stage larvae in each diet series) (Z = zoea; PL = post-larva)

	· · · · · · · · · · · · · · · · · · ·	, (=, F	,		
Molt		Artemia	Algae	Mixed	
ZI	Survival No. (%)*	27(100)	26(96)	26(96)	
to Z II	Age, days Mean Range	2.6 2-3	2.2 2-3	2.2 2-3	
ZII	Survival No. (%)	25(93)	26(96)	26(96)	
to Z III	Age, days Mean Range	4.8 4-7	4.2 4-5	4.4 4-6	
Z III	Survival No. (%)	18(67)	26(96)	25(93)	
to Z IV	Age, days Mean Range	6.7 6–8	6.3 6–7	6.4 6-8	
Z IV	Survival No. (%)	16(59)	22(82)	23(85)	
to Z V	Age, days Mean Range	8.8 8-10	8.9 8-13	8.4 8-10	
ZV	Survival No. (%)	10(37)	17(63)	19(70)	
to Z VI	Age, days Mean Range	11.1 10-12	12.2 10-17	10.5 10-13	
Z VI	Survival No. (%)	0(0)	1(4)	1(4)	
to PL	Age, days Mean Range	-		15	
Z VI	Survival No. (%)	6(22)	11(41)	15(56)	
to Z VII	Age, days Mean Range	13.8 12-15	15.3 13–18	12.7 12-17	
Z VII	Survival No. (%)	0(0)	3(11)	8(30)	
to PL	Age, days Mean Range		18.7 18-22	15.8 15-17	
ZVII	Survival No. (%)	4(15)	5(19)	4(15)	
to Z VIII	Age, days Mean Range	17.0 14-20	19.2 18-20	15.5 14–19	
ZVIII	Survival No. (%)	0(0)	0(0)	4(15)	
to PL	Age, days Mean Range	_		18.5 17–22	
Z VIII	Survival No. (%)	2(7)	2(7)	0(0)	
to Z IX	Age, days Mean Range	20.5 19–22	22.0 21-23	<u> </u>	
ZIX	Survival No. (%)	1(4)	1(4)	0(0)	
to PL	Age, days Mean Range	25	25	_	
Z IX to	Survival No. (%)	0(0)	1(4)	0(0)	
ZX	Age, days Mean Range	_	26 —	=	
ZX	Survival No. (%)	0(0)	1(4)	0(0)	
to PL	Age, days Mean Range	_	29	_	

^{*} Expressed to nearest whole percent

the above-mentioned effects of the mixed diet were due simply to a reduction in the quantity of suitable food ingested by the larvae. Chamberlain (2) supported this hypothesis, and Knowlton (11) recently presented evidence favoring it. Knowlton fed Palaemonetes vulgaris larvae various amounts of Artemia nauplii, and he found that low food levels resulted in increased mortality, increased duration of development, and increased number of molts when compared to high food levels. Regnault (4) also found that in mixed diets Dunaliella and Monochrysis appeared to restrict intake of Artemia nauplii by H. inermis larvae, but he noted that survival of larvae fed a mixed diet of *Phaeodactylum* + Artemia nauplii appeared to be slightly greater than that of the larvae fed only Artemia nauplii.

In the present study, survival of larvae fed a mixed diet of algae and Artemia nauplii was considerably higher than that seen among algae-fed and Arteniafed larvae, and it was evident that both the algae and the Artemia nauplii contributed nourishment to the larvae. The very low percent survival of Arteniafed larvac compared to that seen among algae-fed larvae and larvae fed the mixed diet suggests that Artemia nauplii may be less suitable food for T. floridanus larvae than are certain unicelluar algae. It should be emphasized, however, that since lack of animals prevented repetition of the experiment, it is possible that the extremely low survival seen here among larvae fed only Artemia nauplii docs not reflect the true importance of animal tissue in the nutrition of T. floridanus larvae, Further, development of larvae fed the mixed diet was significantly more rapid than that of larvae fed only algae, and there was a slight (but statistically non-significant) tendency for larvae fed the mixed diet to undergo fewer molts than did algac-fcd larvae. These results suggest that the Artemia nauplii may have supplied some substance, perhaps an amino acid (8), which, while not essential for development, promoted survival and accelerated development. Regnault (4) suggested that unicellular algae were suitable food for *H. inermis* larvae until the second larval molt, at which time animal tissue began to be required. It is interesting that, at about the same time, the larval yolk reserves became exhausted. Perhaps the *Artemia* nauplii replaced the yolk in supplying some substance which is not available from algae.

From the foregoing discussion it is evident that there are differences in the physiology of nutrition among larvae of different species of caridean shrimp. Specifically, larvae differ with regard to degree of requirement for animal food and degree of ability to utilize algae as food. Such differences may even occur at different stages of development of the same larva. Much more study will be necessary before the physiological and ecological significance of such differences in dietary requirements may be understood.

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Physiology of Certain Apple Rot Fungi I. Factors Affecting Growth of Physalospora obtusa in Vitro*

Abstract—The effects of hydrogen ion concentration (pH), nitrogen sources and sucrose utilization on growth of Physalospora obtusa were studied in vitro. The pH had a significant effect on growth, often independent of temperature. The optimum range for growth was pH 7.0 to 9.5 and maximum growth occurred at pH 9.0. During the nitrogen study, the pH of the medium also had a significant effect on growth that was often independent of the nitrogen source. Nitrate nitrogen supported growth better than organic (DL-aspartic acid) or ammonium nitrogen.

Sucrose was hydrolyzed by the fungus regardless of the source of nitrogen. However, utilization of the resulting monosaccharides, glucose and fructose, required specific nitrogen sources, depending on the pH level of the medium. Complete utilization of sugars by the fungus was facilitated by aspartic acid and KNO3 but not by ammonium nitrogen at initial values of pH 5.5 and 9.0.

Introduction

Physalospora obtusa (Schw.) Cke. (Sphaeropsis malorum Peck) causes fruit rot, leaf spot, and branch, limb, and trunk canker of apple (Malus sylvestris Mill.). These diseases are economically important in the midwestern, northeastern, and southeastern sections of the United States.

Although there have been many studies on the effects of light on pycnidium formation and sporulation (1, 2), nuclear phenomena (3), life cycle (4–6) and the control of the pathogen and the diseases it causes (4, 5, 7), the disease syndrome in the fruit

has not been clearly defined.

Lilly and Barnett (8) described the utilization of 12 different sugars by P. obtusa. They found that the fungus utilized all of the sugars but at different rates. Glucose, fructose, and sucrose were utilized more quickly than sorbose, xylose, or lactose. In a later study, Lilly and Barnett (9) showed that with asparagine as a nitrogen source, P. obtusa utilized L- and DL-arabinose more quickly than D-arabinose at a pH of about 5.5. Barnett and Lilly (10) reported on the growth of P. obtusa and the change in pH during growth where the fungus was grown alone

or in combination with a mycoparasite, Calcarisporium parasiticum Barnett on a glucose-potassium nitrate medium adjusted to pH 6.0. They found that P. obtusa grew better on the medium alone than when grown in combination with the mycoparasite. Each fungus developed well together within a pH of 3.2 to 7.0.

Studies are lacking where P. obtusa has been grown on a chemically defined medium and where the source of nitrogen or the initial pH values were varied. A more complete knowledge of the nutritional requirements of P. obtusa is essential to understand better the physiological phenomena involved in pathogenicity of this fungus. The objectives of the present investigation were (i) to study the influence of initial pH and nitrogen sources on the growth of P. obtusa and (ii) to determine the progressive utilization of sucrose by P. obtusa. A preliminary report on a portion of this research has been published (11).

Materials and Methods

A single cultural isolate of *P. obtusa* (1084), obtained from Dr. H. L. Barnett, West Virginia University, and isolated originally from an apple twig, was used throughout the investigation. The pathogenicity of the fungus was demonstrated by inoculating apples and observing typical symptoms periodi-

cally during the investigation.

Experimental procedure. A chemically defined liquid basal medium was used throughout the investigation. Unless otherwise indicated, the basal medium had the following composition: sucrose, 9.5012 g; KH_2PO_4 , 1.0 g; $MgSO_4 \cdot 7H_2O$, 0.5 g; Fe $(NO_3)_3 \cdot$ $9H_2O$, 0.2 mg; MnSO₄· $4H_2O$, 0.1 mg; thiamine, 0.1 mg; biotin, 0.005 mg; and deionized water to make one liter. The nitrogen source was added to the basal medium in an amount equivalent to the nitrogen in 2 g of asparagine. When the nitrogen source was DL-aspartic acid, its carbon equivalent was determined and a quantity of sucrose was added to the basal medium to yield a total of 4.332 g carbon/ liter.

The basal medium and the source of nitrogen

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were sterilized together, but separate from sucrose, at 2X concentrations in an autoclave at 20 psi for 15 min at 121 C. Twenty-five ml aliquots of the sucrose solution were then pipetted aseptically into 250-ml Erlenmeyer flasks that contained 25 ml of the basal medium plus nitrogen. The pH of the combined solutions was adjusted aseptically to the desired pH by adding a predetermined amount of 1N HCl or 1N NaOH.

The inoculum for the various investigations was prepared by incubating the fungus at 28 C on an agar medium that contained the same components as those found in the liquid basal medium. The agar medium was adjusted to pH 6.0 before autoclaving. The medium in each flask was inoculated with a 5 mm disc of mycelium cut from the periphery of a 3-day-old culture. The flasks were incubated as standing cultures in the dark at 28 C.

Growth was determined by harvesting the contents of each flask on previously coded and tared S and S No. 589 White Ribbon filter paper. The filtrates were collected separately and the pH of each was determined. The mycelium was washed on the filter paper with warm deionized water to remove any external material, dried in an oven at 105 C for 24 to 36 hours, and weighed to the nearest mg on a Type H-16 Mettler Balance. Four cultural replicates of each variable (pH, temperature and nitrogen sources) being studied were used at each harvest date.

Preliminary Investigation. A preliminary test was conducted to determine the optimum temperature and initial pH for growth of *P. obtusa*. The liquid basal medium was prepared as previously described except that sucrose was sterilized by Seitz filtration. The pH of the medium was adjusted from 2.5 to 10.5 at 0.5 pH intervals and cultures were incubated at 22, 25, and 28 C. Sucrose and ammonium nitrate were the sources of carbon and nitrogen respectively. The cultures were harvested after incubation periods of 8, 16, and 24 days, respectively.

Nitrogen Investigation. Cultures were incubated at 28 C and initial pH values of 3.5, 5.5, 7.5, and 9.0 for the nitrogen utilization studies. DL-aspartic acid, potassium nitrate, ammonium nitrate, and ammonium sulfate were the sources of nitrogen. A control solution (basal minus nitrogen) was also included. Cultures were harvested at 4 day intervals through 24 days.

Sucrose Utilization. Hydrolysis of sucrose and the progressive utilization of the products by P. obtusa were monitored by ascending paper chromatography of the cultural filtrates within 3 hours of harvest. Cultures were incubated at 28 C and initial pH values of 5.5 and 9.0. Cultures were harvested and the filtrates sampled at daily intervals through 24 days. Approximately 90 μ l of the filtrate from the cultures was spotted on Whatman 3MM paper. Known standards of sucrose, glucose, and fructose were included in each analysis. Ascending chromatography in the solvent, ethyl acetate-pyridine-water (8:2:1, V/V/V), was allowed to proceed for 24 hours before drying. The dried chromatograms were devel-

TABLE I

Dry weight of mycelium of Physalospora obtusa and resultant pH of the medium having sucrose as the carbon source and ammonium nitrate as the nitrogen source at 28 C¹

			Incubation	on (days	s)	
Turitin1	8		1	6	24	
Initial pH	mg	pН	mg	pН	mg	pН
2.5	0 j ²	2.5	01	2.5	01	2.5
3.0	10 i	2.9	27 k	2.8	20 k	2.9
3.5	63 gh	2.8	65 i	2.7	71 fg	3.1
4.0	58 h	2.8	50 j	2.7	47 j	2.7
4.5	59 h	2.6	54 i	2.7	49 j	2.7
5.0	76 f	2.4	75 h	2.6	66 gh	2.6
5.5	77 f	2.7	82 g	2.7	65 h	2.9
6.0	77 f	2.6	75 h	2.5	58 i	2.7
6.5	93 e	2.5	85 g	2.4	76 f	2.6
7.0	108 d	3.1	132 f	2.7	132 e	2.8
7.5	124 c	3.2	156 e	2.9	147 d	3.0
8.0	152 a	3.7	174 d	3.1	148 d	3.7
8.5	134 b	4.8	193 с	3.5	168 c	6.1
9.0	105 d	6.5	216 a	6.2	206 a	7.0
9.5	65 g	7.4	205 b	7.2	194 b	8.2
10.0	0 j	10.0	01	10.0	01	10.0
10.5	0 ј	10.5	01	10.5	01	10.5

¹ Average of eight replicates, four from each of two tests as standing cultures.

 2 Numbers in the same column having different lower case letters are significantly different at the 5% level using Duncan's multiple range method.

oped by dipping in a solution containing 1 ml of aniline, 1 g of diphenylamine, and 10 ml of 85% phosphoric acid per 100 ml of acetone, air dried for 4 to 6 minutes, and heated 5 to 7 minutes at 100 to 105 C.

Results

Initial pH. Growth of the organism was generally homogeneous at the different temperatures (22, 25, and 28 C) and incubation periods (8, 16, and 24 days) for the same initial pH values. However, significant differences were recorded at different initial pH values with the same temperature and different incubation periods. Due to this phenomenon of homogeneous growth, only the results of the data obtained at 28 C are presented (Table I). After eight days, the pH values were lower than the initial pH value and remained lower through the conclusion of the experiment. Optimum growth was recorded at an initial pH 9.0, excellent to good growth occurred at pH 7.0 to 8.5 and 9.5, fair growth at pH 3.5 to 6.5, least growth at pH 3.0, and no growth at pH 2.5, 10.0, or 10.5. Two definite growth peaks occurred after an incubation period of 16 days (Table I). One peak occurred when the initial pH was 3.5 while the second and higher peak occurred when the initial pH was 9.0. Autolysis was generally evident after 16 days of incubation.

Nitrogen Source. Potassium nitrate was the best source of nitrogen for growth regardless of the pH value (Fig. 1). Optimum growth was recorded on or after the 16th day at all pH values tested. Pycnidia were abundant after 10 days of incubation

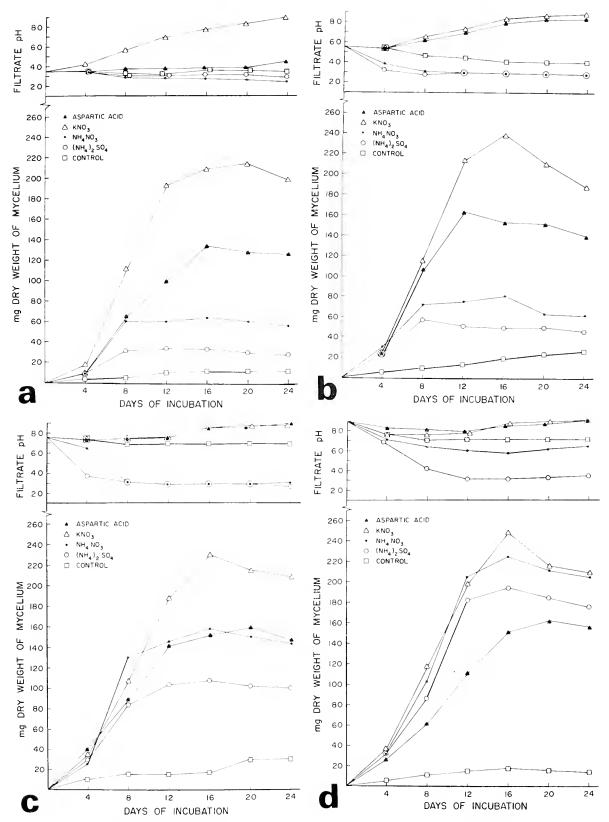


Fig. 1—Effect of initial values of pH (a) 3.5, (b) 5.5, (c) 7.5, and (d) 9.0 and different nitrogen sources on growth of *Physalospora obtusa* in a basal liquid medium incubated at 28 C with sucrose as the carbon source.

but well defined stromata were not formed until after 13 days of incubation.

Growth was greater when the initial pH values were 5.5, 7.5, and 9.0 than at a pH value of 3.5 when DL-aspartic acid was the nitrogen source. Maximum growth occurred by the 12th day at an initial pH 5.5, the 16th day at an initial pH 3.5, and the 20th day at initial pH 7.5 and 9.0 (Fig. 1). Compact stromata developed after four days incubation in all cultures except those growing in a medium at an initial pH 3.5 where growth appeared

as a dispersed accumulation of stromata. Pycnidium formation was sparse.

Amonium nitrate was a better source of nitrogen for growth of *P. obtusa* than (NH₄)₂SO₄ (Fig. 1). Optimum growth occurred when the initial pH was 9.0 for both NH₄NO₃ and (NH₄)₂SO₄. In NH₄NO₃ treatments, maximum growth was obtained after 16 days of incubation at all pH values. When (NH₄)₂SO₄ was the nitrogen source, maximum growth occurred after 12 days of incubation at an initial pH 3.5, 8 days at pH 5.5, and 16 days at pH 7.5 and

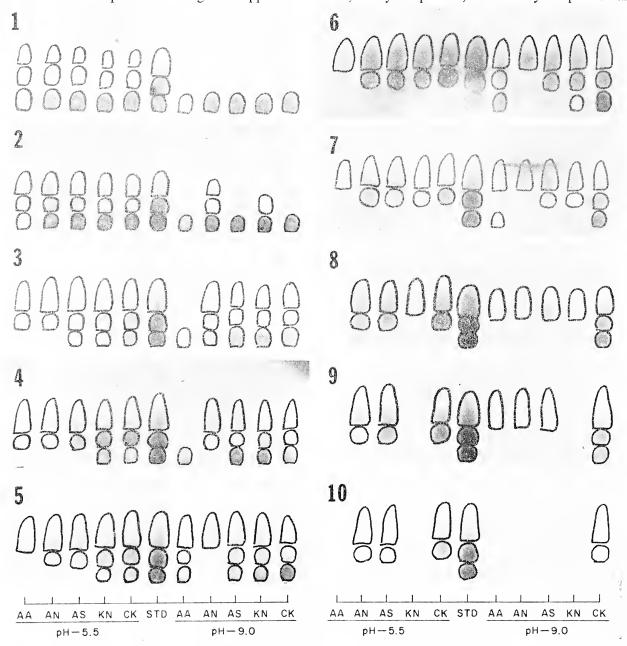


Fig. 2—Ascending paper chromatography showing hydrolysis of sucrose and progressive utilization of sucrose, glucose and fructose by *P. obtusa* with four nitrogen sources (AA. Aspartic Acid; AN, NH₄NO₅; AS, (NH₄)₂SO₅; KN, KNO₅; CK, Control (minus nitrogen): and STD, sucrose, glucose, fructose standard) in the basal liquid medium at initial values of pH 5.5 and 9.0. The number on each chromatogram refers to the incubation period: 1, 1 day; 2, 2 days; 3, 4 days; 4, 6 days; 5, 8 days; 6, 10 days; 7, 12 days; 8, 15 days; 9, 18 days; and 10, 24 days. The lower row of circled spots on each chromatogram represent (sucrose) Rf, middle row (glucose) Rf, and the upper row (fructose) Rf. The spots were circled immediately after the chromatogram was removed from the oven.

9.0. The most rapid growth occurred during the first 8 days of incubation when the initial pH values were 3.5, 5.5, and 7.5 and during the first 12 days at pH 9.0 for both NH₄NO₃ and (NH₄)₂SO₄. When either NH₄NO₃ or (NH₄)₂SO₄ was the nitrogen source, compact stromata appeared after 8 days of incubation at all pH values but pycnidium formation was sparse.

Growth in the control cultural solution (basal medium minus nitrogen) at the four pH values resembled that of a watery, gelatinous mass and at no time was distinct mycelium observed. Although growth was minimal at all pH values, it was slightly

better at pH 5.5 and 7.5.

Sucrose Utilization. The results of the chromatographic analyses to test for progressive sucrose hydrolysis are shown in Fig. 2. Only those chromatograms are shown that represent significant change in sugar utilization. The hydrolysis of sucrose by *P. obtusa* when aspartic acid was the nitrogen source occurred after one day of incubation at an initial pH 5.5 but was not observed until the 8th day with an initial pH 9.0. All sugars were utilized between the 12th day and 15th day at an initial pH 5.5 and between the 18th and 24th day at an initial pH 9.0.

Partial hydrolysis of sucrose was observed one day after incubation of the media at an initial pH 5.5 but not until the 2nd day at pH 9.0 when KNO₃ was the nitrogen source. Complete utilization of the sugars by *P. obtusa* at both initial pH values occurred between the 15th and 18th day of incubation.

Complete utilization of the sugars by the fungus was facilitated by DL-aspartic acid and KNO₃ at both pH values. The sugars were completely utilized at an initial pH 9.0 but not at pH 5.5 when NH₄NO₃ and (NH₄)₂SO₄ were the nitrogen sources. The sugars were not completely utilized at either pH value in the control. Except for DL-aspartic acid at an initial pH 9.0, the sequence of sugar utilization by *P. obtusa* at both initial pH values was sucrose, followed by glucose, then fructose.

Discussion

Pycnidium formation was more abundant in basal medium containing KNO₃ than when other nitrogenous sources were used. It was also found to be true when the fungus was grown on a solid medium containing the same nutrients. Since *P. obtusa* sporulates poorly on many laboratory media the use of KNO₃ in a solid medium should be investigated further in relation to spore formation even though sporulation did not occur during this investigation. Spores did not form because these standing cultures were kept in the dark and it has been determined that light is necessary for sporulation of *P. obtusa* (1, 2).

Decreases in pH occurred when either NH₄NO₃ or (NH₄)₂SO₄ was used as a nitrogen source. Barnett and Lilly (10) reported a decrease in pH of a (NH₄)₂SO₄-glucose liquid basal medium during the growth of *Physalospora glandicola* (Schw.) Stevens. This decrease was similar to that observed during this investigation with *P. obtusa*. Skirahawa (12) and Haskins and Weston (13) also reported sig-

nificant decreases in pH with different genera of fungi cultured with ammonium nitrogen. According to Lilly and Barnett (14), other things being equal, one would expect an increase in pH with utilization of nitrate ions and a decrease in pH with the utilization of ammonium ions. If *P. obtusa* were able to utilize at the same rate, both ammonium ions and nitrate ions of NH₄NO₃ the pH should have remained relatively stable. Since there was a consistent decrease in pH when NH₄NO₃ was the nitrogen source, the overwhelming evidence indicated that *P. obtusa* utilized ammonium nitrogen preferentially to nitrate nitrogen. Cochrane (15) indicated that some fungi utilize virtually all the ammonium nitrogen before they start to utilize the nitrate nitrogen of NH₄ NO₃.

When DL-aspartic acid served as the nitrogen source, hydrolysis and subsequent utilization of sucrosc and the resulting monosaccharides were accomplished more rapidly at an initial pH 5.5 than at pH 9.0. This may well indicate why optimum growth by the fungus was reached sooner at an initial pH

5.5 (compared to pH 9.0 initially).

The reason for suppression of growth and incomplete utilization of glucose and fructose in a medium at an initial pH 5.5 and not at pH 9.0 when NH₄NO₃ and (NH₄)₂SO₄ served as the sources of nitrogen is not clear. However, a suggestion is offered that may explain this phenomenon. The initial pH 5.5 of the medium decreased to pH 2.8 to 2.9 after 8 days of incubation. This low pH could have prevented *P. obtusa* from utilizing either glucose or fructose and, therefore, suppressed growth.

The progressive utilization of sugars by *P. obtusa* after hydrolysis of sucrose in a liquid basal medium having initial values of pH 5.5 or 9.0 with KNO₃ as the nitrogen source may be attributed to the fact that the pH of the basal medium did not decrease to

growth suppressing levels.

Conclusion

This investigation has shown that pH has a significant effect on growth of P. obtusa, often independent of the nitrogen source and temperature. It also was shown that the optimum range of the initial pH for growth of the fungus was between pH 7.0 to 9.5. Further, it was demonstrated that sucrose was hydrolyzed by the fungus growing on all nitrogen sources. However, utilization of the resulting monosaccharides, glucose and fructose, required specific nitrogen sources depending on the pH of the medium. Thus, pH and its effect on nitrogen assimilation and the resulting sugar utilization constituted a major influence on nutrition of P. obtusa in vitro. This interaction phenomenon as well as the strongly alkaline pH optimum for growth may also influence pathogenicity of the organism in nature.

The alkaline pH optimum for maximum growth may help explain the slow colonization of apple fruit by *P. obtusa*. The pH of apple fruit is approximately 4 and although some growth occurred at pH 4.0 (Table I), it was slow and seemed to parallel that

of slow colonization of the apple in nature.

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A Note on the Simultaneous Diagonalization of Two Real, Symmetric Matrices

In statistics it is sometimes useful to simultaneously diagonalize two real, symmetric matrices, A and B. For example, Rao (1), among others, uses this to display canonical correlation coefficients as elements of a diagonal matrix. It is well known (1–4) that if B is positive definite there exists a non-singular matrix R such that

 $R'AR = \Lambda$, where Λ is a diagonal matrix

and

$$R'BR = I.$$

The fact that there exists a matrix Q with similar properties when B is negative definite does not appear to be well known. It is the purpose of this note to prove that result.

Theorem: Given that A and B are real, symmetric matrices and that B is definite (positive or negative), there exists a non-singular matrix Q such that

Q'AQ is diagonal

and

$$Q'BQ = I$$

Proof: Case I: B is positive definite. For the proof to this see (3).

Case II: B is negative definite.

Since B is a symmetrie, negative definite matrix there exists an orthogonal matrix P which reduces B to a diagonal matrix of its eigenvalues; i.e.

$$P'BP = diag.(\theta_1, \theta_2, \cdots, \theta_k) = \theta,$$

$$\theta_i < 0, i = 1, 2, \cdots, k.$$

Call ⊖-1/2 the diagonal matrix whose ith diagonal ele-

ment is $\Theta_i^{-1/2}$, $i=1,2,\cdots,k$. (Note that the nonzero elements of $\Theta^{-1/2}$ are all purely imaginary.) Now we have

$$\Theta^{-1/2} P' B P \Theta^{-1/2} = I.$$

Consider now the matrix

$$\Psi = \Theta^{-1/2} P' A P \Theta^{-1/2}.$$

Since the diagonal elements of $\Theta^{-1/2}$ are purely imaginary, Ψ contains only real elements. Notice also that it is a symmetric matrix. Therefore, there exists an orthogonal matrix S such that S' Ψ S is a diagonal matrix and

$$S'[\Theta^{-1/2}P'BP\Theta^{-1/2}]S = S'S = I.$$

Thus,

$$Q = P\Theta^{-1/2}S$$

is the matrix which simultaneously diagonalizes A and B.

Since, in applications, one is merely interested in the existence of Q, the fact that Q is imaginary is of no consequence.

Numerical Example:

Let A =
$$\begin{bmatrix} 10.6 & 5.2 & 7.3 \\ 5.2 & 6.2 & 8.0 \\ 7.3 & 8.0 & 4.6 \end{bmatrix}$$
 and B =
$$\begin{bmatrix} -13.4 & -11.4 & -17.6 \\ -11.4 & -14.2 & -13.6 \\ -17.6 & -13.6 & -26.4 \end{bmatrix}$$
.

The eigenvalues of B are -0.6682, -5.3946, and -47.9371. The orthogonal matrix P which is such that P'BP is a diagonal matrix is

$$\mathbf{P} = \begin{bmatrix} 0.8548 & 0.0006 & 0.5190 \\ -0.2827 & 0.8392 & 0.4646 \\ -0.4353 & -0.5438 & 0.7175 \end{bmatrix}$$

In this example

$$\Theta^{-1/2} = \begin{bmatrix} 1.2233i & 0 & 0 \\ 0 & 0.4305i & 0 \\ 0 & 0 & 0.1444i \end{bmatrix}.$$

Notice that

$$\Theta^{-1/2} \mathbf{P'BP} \Theta^{-1/2} = \begin{bmatrix} 0.9999 & 0.0000 & 0.0000 \\ 0.0000 & 0.9999 & 0.0000 \\ 0.0000 & 0.0000 & 0.9998 \end{bmatrix}$$

The orthogonal matrix S which diagonalizes $\Theta^{-1/2}$ P'AP $\Theta^{-1/2}$ is

$$S = \begin{bmatrix} 0.9787 & -0.0556 & 0.1974 \\ -0.1664 & 0.3474 & 0.9228 \\ 0.1199 & 0.9361 & -0.3307 \end{bmatrix}$$

Finally, the matrix which simultaneously diagonalizes A and B is

$$Q = P\Theta^{-1/2}S = \begin{bmatrix} 1.0324i & 0.0120i & 0.1818i \\ -0.3905i & 0.2076i & 0.2430i \\ -0.4698i & 0.0453i & -0.3554i \end{bmatrix}$$

In this case

$$Q'AQ = \begin{bmatrix} 4.9202 & 0 & 0 \\ 0 & 0.4626 & 0 \\ 0 & 0 & -0.5683 \end{bmatrix}.$$

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Effects of Dimethylsulfoxide on Polyuridylic Acid-Directed Polypeptide Synthesis by *Escherichia Coli* Ribosomes

Abstract-Dimethylsulfoxide (DMSO) altered the relative and absolute incorporation of phenylalanine and isoleucine by a polyuridylic acid-directed polypeptide synthesizing system employing Escherichia coli K-12 ribosomes. At suboptimal Mg++ concentrations (<24 mM) DMSO stimulated phenylalanine but not isoleucine incorporations; at optimal or supraoptimal Mg++, DMSO was inhibitory but caused little misreading. Changes in the amount of phenylalanine and isoleucine incorporation as a function of increasing concentrations of Mg⁺⁺ and DMSO singly and in combination showed that Mg⁺⁺ and DMSO were synergistic. In contrast ethanol was inhibitory at all Mg++ concentrations and caused a differential increase in isoleucine incorporation. DMSO reversed the inhibition of phenvlalanine incorporation by streptomycin at suboptimal Mg++ concentrations and significantly reduced streptomycin-induced ambiguity. The synergistic relationship between DMSO and Mg++ and the antagonistic relationship between DMSO and streptomycin indicates that DMSO uniquely alters ribosomal conformation.

Introduction

Dimethylsulfoxide (DMSO) is a highly polar organic solvent which possesses many unusual pharmacologic properties (1). Foremost is the ability of DMSO to alter selectively the permeability of mammalian and bacterial cell membranes (1, 2). DMSOinduced changes in cellular permeability and in the activity of certain enzymes under physiological conditions has been postulated to result from the interaction of DMSO with bound water molecules (1) and with divalent cations (3, 4). Most bacteria, fungi and parasites are inhibited by DMSO concentrations of 20% or less (5-8). Subinhibitory concentrations, however, can reversibly alter the phenotypic characteristics of a microorganism (1). Fowler and Zabin observed that mutants of Escherichia coli which were cryptic toward lactose, could utilize lactose for growth in a minimal medium containing 5% DMSO (2). Recent studies in this laboratory have shown that a mutant of E. coli K-12 which is chromosomally resistant to $>5,000 \mu g$ streptomycin (STR) per ml became sensitive to 5 μ g STR/ml in the presence of non-inhibitory concentrations of 5-8% DMSO, and that 3-8% DMSO could satisfy the STR requirement of a non-conditional STR-dependent *E. coli* K-12 mutant (9, 10). The change in resistance concomitant with increased uptake of ¹⁴C-STR by the resistant cells and the apparent interaction of DMSO with ribosomes in the dependent cells indicated that low concentrations of DMSO may functionally alter both the membrane and ribosomes in *E. coli*. This communication describes our observations on the effects of DMSO in the presence and absence of STR on a cell-free polyuridylic acid-directed polypeptide synthesizing system using *E. coli* K-12 ribosomes.

Materials and Methods

Bacterial culture and preparation of cells. E. coli K-12 substrain CSH-2 (Met-, Pro-) which is sensitive to 5 μ g STR/ml was used for all experiments. Liter cultures were grown with shaking for 18 hr at 37 C in the minimal medium of Davis and Mingiolli (11) supplemented with 0.2% glucose and 0.1% vitamin-free casamino acids (Difco). Cells were collected by centrifugation at 10,000 \times g for 10 min at 0 C and washed with 100 ml of cold buffer (0.06 M ammonium chloride, 0.01 M magnesium acetate, 0.01 M tris(hydroxymethyl)aminomethane (Tris) and 6 mM β -mercaptoethanol; pH 7.4). The average yield was 2 g cells (wet weight) per liter. Washed cells were rapidly frozen and stored until used.

Preparation of ribosomal and supernatant fractions. Ribosomal and supernatant fractions were prepared according to the method of Anderson, Gorini and Breckenridge (12), except that deoxyribonuclease was not added to the cell extract. Ribosomal protein was determined by the method of Lowry, et al. (13).

Incubation conditions. Incorporation of ¹⁴C-phenylalanine (New England Nuclear) and ³H-isoleucine (New England Nuclear) into hot trichloroacetic acid-insoluble material was determined by a modification of the procedure of Anderson, Gorini and Breckenridge (12). Components, listed in the order of addition, in the system were: adenosine triphosphate (Na salt), 10⁻³ M; guanosine triphosphate

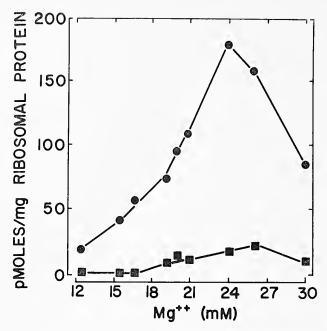


Fig. 1—Phenylalanine and isoleucine incorporation at various Mg** concentrations. Phenylalanine — — — and isoleucine — — — expressed in pmoles per mg ribosomal protein.

(Na salt), 10⁻⁴ M; phosphoenol pyruvate (K salt), 5mM; phosphoenol pyruvate kinase (Calbiochem; sp. act. 2.62 I.U./mg protein), 7.5 μ g; β -mercaptoethanol, 6 mM; soluble ribonucleic acid (Calbiochem), 100 μ g; polyuridylic acid (Poly U, Calbiochem), 20 μ g; 14 C-phenylalanine (sp. act. 375 μ c/ μ M), 0.04 μ c; 3 H-isoleucine (sp. act. 1770 μ c/ μ M), 0.04 μ c; 12 C-amino acids, 0.52 μ g each (except phenylalanine and isoleucine); magnesium acetate (Mg++) as indicated in Results; ammonium chloride, 35 mM; Tris, 89 mM, pH 7.8; soluble enzyme fraction, 108 μ g; ribosomal protein, 0.154 mg; DMSO and STR as indicated in **Results**; and distilled water to a total volume of 0.25 ml. Reactions were begun by the addition of the ribosomes to the mixtures at 37 C. Samples were removed at 0 and 30 min, treated according to the filter disc procedure of Mans and Novelli (14), and counted in a Packard Tri-Carb scintillation spectrometer. The pmoles of ¹⁴C-phenylalanine and ³H-isoleucine incorporated per mg ribosomal protein were calculated as described by Chase and Rabinowitz (15).

Results

Properties of the poly U-directed system. The pmoles of ¹⁴C-phenylalanine and ³H-isoleucine incorporated by the reaction mixture was dependent upon an energy generating system, poly U, and both the ribosomal and supernatant fractions. Maximal phenylalanine incorporation (180 pmoles/mg ribosomal protein) occurred with 24 mM Mg⁺⁺, and decreased progressively as the Mg⁺⁺ concentration was increased (Fig. 1). Isoleucine incorporation was minimal in Mg⁺⁺ concentrations below 16.6 mM but increased to a value of 21 pmoles/mg ribosomal

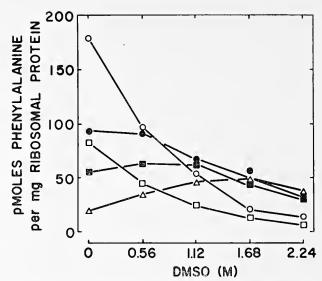


Fig. 2—Effect of DMSO on phenylalanine incorporation at various Mg** concentrations. Mg** concentrations were: 12.3 mM, \triangle —— \triangle ; 16.6 mM, \blacksquare —— \blacksquare ; 20 mM, \blacksquare —— \blacksquare ; 24 mM, \bigcirc —— \bigcirc ; and 30 mM, \square —— \square .

protein at 26 mM Mg⁺⁺. The amount of each amino acid incorporated after 30 min incubation at the optimal Mg⁺⁺ concentration was always 20 fold or greater than the respective 0 time control. These results are comparable to and consistent with the characteristics of the poly U-directed system from this organism described by previous workers (16–20).

Effect of DMSO on phenylalanine incorporation. The degree of stimulation or inhibition of phenylalanine incorporation by DMSO was strictly dependent upon the Mg⁺⁺ concentration (Fig. 2). At 12.3 mM Mg⁺⁺, marked stimulation of phenylalanine incorporation which showed a concentration dependent response between 0 and 1.68 M DMSO was observed. With higher Mg⁺⁺ concentrations DMSO became progressively less stimulatory, and at the optimal (24 mM) or higher Mg⁺⁺ concentrations all concentrations of DMSO were inhibitory.

Effect of streptomycin and DMSO-streptomycin combinations on phenylalanine incorporation. At a given Mg⁺⁺ concentration, more inhibition was observed with the higher STR concentration (Table I). High Mg⁺⁺ concentrations, however, tended to reverse the inhibition at both STR concentrations. At 16 mM Mg⁺⁺ (Fig. 3A), the inhibition caused by

TABLE I Inhibition of phenylalanine incorporation by streptomycin at various Mg^{++} concentrations

Mg ⁺⁺ (mM)	6.9 μM STR	13.8 μM STR		
	Percent decrease ¹			
16	35	36		
20	52	61		
24	48	64		
30	19	46		

¹ Expressed as the percent decrease compared to the control without streptomycin.

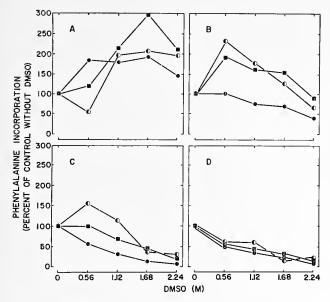


Fig. 3—Effect of various DMSO-streptomycin combinations on phenylalanine incorporation at different Mg** concentrations. Values are expressed as a percent of the phenylalanine incorporated in the control without DMSO at 16.0 mM Mg** (A), 20 mM Mg** (B), 24 mM Mg** (C), and 30 mM Mg** (D). (without streptomycin, \bullet —— \bullet ; with 6.9 μ M streptomycin, \bullet —— \bullet ; and with 13.8 μ M streptomycin, \bullet —— \bullet).

6.9 μM STR was reversed by all DMSO concentrations tested; maximal reversal occurred with 1.68 M DMSO. Similarly, but to a lesser extent, the inhibition caused by the higher STR concentration (13.8 μM) was also reversed by DMSO. In both instances the STR-DMSO combinations were more stimulatory than DMSO alone. Likewise, stimulation occurred with both STR concentrations in 1.68 M DMSO or less at 20 mM Mg** concentration, while DMSO alone was inhibitory (Fig. 3B). At the optimal Mg** concentration (Fig. 3C), only the lower concentration of DMSO with 13.8 μM STR increased phenylalanine incorporation while all DMSO concentrations and DMSO-STR combinations were inhibitory at 30 mM Mg** (Fig. 3D). Thus, although STR singly was inhibitory at all Mg** concentrations (Table I), STR-DMSO combinations were more stimulatory (Fig. 3A, B) than DMSO alone at low Mg** concentrations (Fig. 2) and STR reversed the

TABLE III

The effect of ethanol on phenylalanine and isoleucine incorporation at various Mg++ concentrations

•	J		
Mg++ (mM)	Ethanol (%)	Phenyl- alanine ¹	Isoleu- cine ²
	0	91	14
20	4	32	18
	8	21	22
	0	122	16
24	4	45	20
	8	24	28
	0	88	20
30	4	19	36
	8	7	27

¹ pmoles/mg ribosomal protein

inhibitory effect of DMSO at the optimal Mg⁺⁺ concentration (Fig. 3C).

Effect of DMSO, streptomycin and ethanol on isoleucine incorporation. Isoleucine incorporation in a poly U-directed system provides a measure of the ability of antibiotics and chemicals to cause misreading of the genetic code (16). In the absence of DMSO and STR, isoleucine incorporation increased with increasing Mg⁺⁺ concentrations (Table II). The addition of STR at all Mg⁺⁺ concentrations caused more misrcading, while misreading was noted only with high DMSO concentrations when compared to the controls without DMSO or STR. In contrast to the synergistic effect on phenylalanine incorporation (Fig. 3), DMSO-STR combinations only slightly increased isoleucine incorporation at 16 and 20 mM Mg⁺⁺ and were generally inhibitory at higher Mg⁺⁺ concentrations. Thus, low DMSO concentrations appeared to decrease the STR-induced misreading at optimal and higher Mg++ concentrations.

Since ethanol has also been reported to increase misreading in a poly U-directed system (19, 20), the effect of 4 and 8% ethanol (0.69 M and 1.38 M, respectively) on phenylalanine and isoleucine incorporation in our system at various Mg⁺⁺ concentrations was determined. Ethanol inhibited phenylalanine incorporation at all Mg⁺⁺ concentrations and the degree of inhibition showed a positive correlation with ethanol concentration (Table III). The

TABLE II

The effect of DMSO and streptomycin on misreading at various Mg⁺⁺ concentrations

			ules isoleuci M Mg++		M Mg ⁺⁺		M Mg ⁺⁺	30 ml	M Mg ⁺⁺	
	DMSO (M)	STR	R (μM)	STR (µM)		STR (µM)		STR (µM)		
		0	13.8	0	13.8	0	13.8	0	13.8	
	0	8	18	12	20	14	25	20	33	
	0.56	10	34	14	19	15	17	15	21	
	1.12	15	20	16	19	17	20	19	21	
	1.68	15	22	24	19	23	22	28	28	
	2.24	17	23	21	21	34	25	29	32	

² Expressed as molecules isoleucine per 100 molecules phenylalanine incorporated.

reverse was observed for isoleucine incorporation; misreading was significantly increased at all Mg+ eoneentrations. Thus, DMSO (Fig. 3, Table II) and ethanol (Table III) produced opposite effects on both phenylalanine and isoleueine incorporation.

Discussion

Although Wacker and Mohrbutter (21) have previously reported that 10% DMSO stimulated phenylalanine incorporation in a poly U system at 10 mM Mg⁺⁺, the effect of different DMSO, Mg⁺⁺, and STR eoneentrations and eombinations on phenylalanine incorporation and misreading were not investigated. The results presented in this report suggest that DMSO has eertain unique effects on a poly U-directed system from E. coli K-12. In contrast to the general inhibition observed with ethanol and STR, DMSO stimulated phenylalanine ineorporation at suboptimal Mg⁺⁺ and was inhibitory only at optimal and supraoptimal Mg⁺⁺ eoneentrations. These observations indicate that DMSO and Mg++ act synergistically at the ribosomal level. This interpretation is eonsistent with the similarly observed effects of increasing eoneentrations of DMSO and Mg++ on isoleueine incorporation.

The levels of misreading observed with STR and ethanol in these studies were somewhat lower than those reported by other investigators (16, 19, 20). Our lower values might reflect a competitive effect between the labeled isoleucine and the relatively high concentration of tyrosine, serine, and leucine present in the ineubation mixture (16). The possibility that the higher innate level of isoleucine incorporation in our system masked small levels of DMSO-induced

misreading cannot be excluded.

Since STR specifically interacts with the 30 S ribosomal subunit (16, 17, 22, 23), the antagonistic effect of DMSO on STR inhibition and ambiguity might reflect a DMSO-induced conformational change in the 30 S ribosomal eomponent. However, the synergistic relationship between Mg++ and DMSO indicates that the effects of DMSO are not necessarily limited to a single site, and that the varied effects of Mg⁺⁺ would be mimicked by DMSO. Thus, it seems likely that DMSO might cause a variety of eonformational ehanges in ribosomes and affect the association-dissociation of the 30 S-50 S subunits of the poly U-ribosomal subunits.

The ability of DMSO to stimulate phenylalanine incorporation, reverse the inhibitory effects of STR at suboptimal Mg++ concentrations and reduce misreading at optimal or higher Mg++ concentrations appears to be a unique property not observed with other solvents (19, 20). In eonjunction with previous findings that DMSO can affect the phenotypic expression of STR resistance and dependence and the recent report by Momose and Gorini (23) that the ribosomal component coded by the Str A locus is not the specific site of STR action, it is conceivable that the allelie change associated with STR resistance and dependence genotypes might result in a reduced

intracellular Mg++ concentration concomitant with the altered 30 S ribosomal protein (22). Regardless of the eausative or eonsequential role a reduced intracellular Mg++ concentration might play in the expression of STR resistance and dependence, the existence of a Mg++ deficiency in these genotypes might be reflected in the differential response of sensitive, resistant and dependent eells to STR in media eontaining various Mg⁺⁺ eoneentrations (17).

Acknowledgments

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Mapping the Seasons in Virginia-You Can Help

Have you ever wondered why the seasons of the year and attendant plant responses differed in different parts of our state and the country? Your answer may be "Yes, but that's obvious, it's north or south of here;" or, "... everyone knows tide-water isn't the same as the mountains." The seasons we are familiar with are mainly temperature and day length phenomena caused by different positions of the earth in relation to the sun. The seasons have been a very dominant force through eons of time, influencing the evolution of our ecosystems and the organisms that live in them.

The International Biological Program (IBP) is now correlating ecological investigations gathering information on biological phenomena as they occur in the different major life regions (biomes) of the world. Virginia is only one state in many located in the Eastern Deciduous Forest Biome; many researchers are contributing a wide variety of data to this biome phase of the project, from all over the eastern United States, to the project headquarters at Oak Ridge National Laboratories, Oak Ridge, Tennessee. Here in Virginia I am conducting and directing a state-wide compilation of phenological data in cooperation with IBP and also with colleagues at the University of North Carolina where the computerization of data is being accomplished. More specifically I am attempting to plot the seasons, especially the onset of Spring and Fall. Phenology deals with the timing and understanding of the appearances of various life events (birth to death) in individuals and communities of organisms as related to environmental rhythms and variations, basically climate.

Dogwood (Cornus florida L.) and Redbud (Cercis canadensis L.) flowering times have been determined to be the most obvious and also the largest indicators of the arrival of spring in our area—so obvious in fact that remote sensing from airplane or satellite would not be impossible after more concentrated ground studies are completed. Red Maple (Acer rubrum L.) will be added to these spring data during future observations. The arrival of fall is being judged by the timing of leaf coloration on the Red Maple and Tulip Poplar (Liriodendron tulipifera L.) trees. I will be attempting to correlate these events of nature with many climatic parameters, such as day length, temperature, latitude, altitude, and others, but only if I collect an adequate quantity of data (and this is where all Virginians can help).

There are very few consistent phenological reports from this part of the United States from which to draw significant conclusions to date. I am just completing compilation of the first year's data in Virginia thanks to the help and cooperation of a network of just over 500 observers from almost all parts of the state. These 500 are the responses received from some 3600 letters sent out in early spring 1971, to VPI county extension agents, Virginia Federation of Garden Clubs, Mary Baldwin Alumnae in the state, University, College, and High School biology and/or botany departments and selected biologists and botanists of the Virginia Academy of Science. University of North Carolina ecologists started a network of observers two years ago, to collect similar phenological data. Their data and our data will be more and more meaningful as the size of the area sampled and quantity of samples per area continues to expand.

The phenological data and known environmental parameters are computer programmed and mapped for the entire state; therefore, it is absolutely essential that our data be as accurate and complete—from all parts of the state—as possible. Although there were gaps in the Spring 1971 data (Fig. 1), the 500 replies were adequate enough to enable construction of isophene maps (Fig. 2, 3). The number of data responses per county for redbud were not quite as numerous as for the dogwood; therefore, the number of counties (nineteen) with no recorded data for redbud was greater than the ten counties left blank for dogwood. Meaningful statistical analysis can not be accomplished until the responses returned total at least ten per county per season. As all of us know, the climate and scasons can and do vary each year; therefore, I would like to determine a five-year average for each species being studied. This should give reliable enough data to determine the relationships of spring flowering and fall coloration to specific environmental parameters throughout the state. By having both spring and fall data I can also determine the length of the growing seasons. The fall data were only just arriving in Staunton at the writing of this report, but appear to be a much lighter response than during the spring. We will need added interest and effort during coming fall seasons to gather adequate data statewide.

Our most meaningful data to date are mapped and shown in figure 4. Here the dogwood and redbud

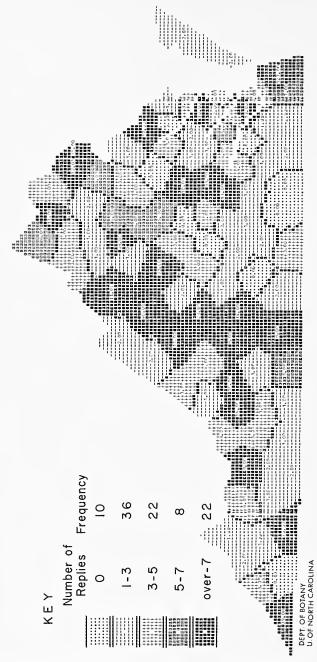


Fig. 1—Number of replies per county of dogwood (Cornus florida) flowering dates during spring 1971.

data have been combined and mapped. The southern boundary of this particular phenology map matches almost perfectly the northern boundary of the North Carolina phenology map, even with our data gaps. Again, this should be expected, but we have been able to show it quantitatively from two states with a common boundary, whose maps were constructed independently of each other.

I would like to take this opportunity to thank each individual who provided me with information for his area this past year. I can not thank everyone personally or enough but several people merit special recognition for their efforts during the spring of 1971, as

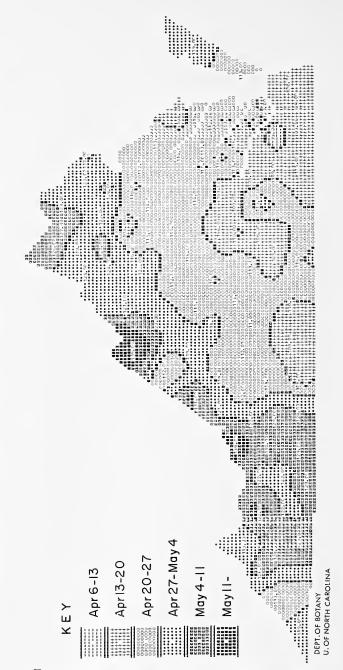


Fig. 2—Estimated arrival of spring 1971 based on the average flowering dates per county of dogwood (*Cornus florida*) throughout the state of Virginia. Data value extremes are April 9 to May 19.

they either sent in more than one report, or organized their own group of observers and duplicated my response form: Michael Bowman, B. F. D. Runk, U. Va. Biology Department (Albemarle); H. A. Holmes (Amelia); E. Sprague, Sweet Briar College; Pamela von Tassele (Amherst); Charlisie B. Tarantola, Oak Ridge Elementary School; Josephine E. Wood, Groveton High School (Arlington); James W. Engle, Jr.; Samuel Foster (Augusta); Frank Hotz, E. C. Glass High School; William H. Jenkins, Virginia Episcopal School (Bedford, Campbell); Twink Lewis, Hollins College (Botetourt); Lee Marshall,

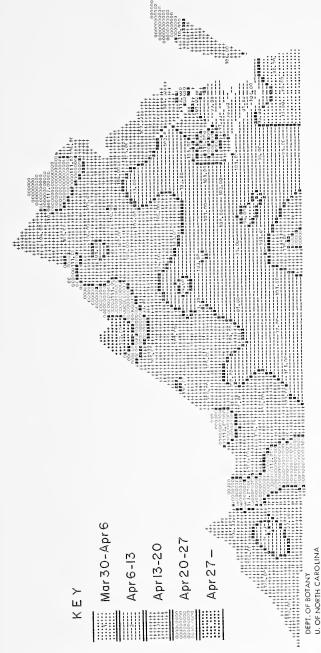


Fig. 3—Estimated arrival of spring 1971 based on the average flowering dates per county of redbud (Cercis canadensis) throughout the state of Virginia. Data value extremes are March 31 to May 2.

SVCC, (Buchanan, Tazewell); Elizabeth Phillips, Altavista High School Biology class; Bill Sladys (Campbell); Mrs. A. T. Brooks (Chesterfield); Mrs. Rice Levi, High School class (Clarke); Mrs. Charles H. Dick (Frederick and others); Mrs. Wellford L. Sanders (Henrico); Mrs. Thomas L. Grove (King and Queen, Essex); Elizabeth Harris, Jonesville 9th grade General Science class (Lee); R. B. Shaw (Louisa); G. T. Dewey, Woodberry Forest School (Madison); Christchurch School Science class (Middlesex); P. P. Feret, V.P.I. SU Forestry and Wildlife; L. J. Uttal, V.P.I. SU Biology Department (Mont-

gomery); B. Lloyd Nice, Denbigh High School (Newport News); Mrs. B. Lee Kagey (Rockbridge); Bridgewater College Botany class (Rockingham); Mrs. Edward S. Taylor, Weber S. Taylor (Stafford and King George); Jeffrey Barr, Freddie Fink, Shep Fleet, Stephen A. Henderson, H. B. Hunter, III, Frank MacConochie, Randy Perrie (Virginia Beach); G. E. Treadwell, Jr., Emory and Henry College Biology Department (Washington) and Suzanne K. Tolson (Westmoreland). Special thanks must also go to the personnel of the University of North Carolina botany department, especially Mr. Richard Reader, who produced the maps of our data with their computer. This initial phase of the project was also partially funded by Mary Baldwin College, Staunton, Virginia.

Dogwood and Redbud flowering isophenes (zones of similar or close ranging dates) are very similar on the Virginia map, showing the expected northwestward progression of flowering dates. Spring arrives first in Virginia Beach and last in the West to Northwest mountains. Although this is not news to most of us as observers this is the first statewide quantification of this type of data which makes it very exciting. The success of the method of collecting large amounts of meaningful and scientifically useful data from a corps of such cooperative volunteers is truly noteworthy. Isolated deviations from the isophenes can usually be explained by the lack of replies from that particular area. Even present flowering patterns seem to indicate a strong quantitative relationship between elevation and geographical location of an

area and its flowering dates.

County data composed of fewer than ten responses were not considered statistically sound for use in any correlation analyses. Because of their similarities, dogwood and redbud data were combined to provide county average flowering dates. Thirty Virginia counties did have ten or more data responses (dogwood plus redbud). These data were used in linear regression analyses between average altitude of trees sampled and their flowering dates (Fig. 5). Two linear regression equations—A) for counties north of 37° 30' N, and B) for counties south of 37°30'N—express the relationships between altitude and flowering dates better than one equation for all counties.

A. Flowering Date

= (.0048) (elevation in feet) + 108.62

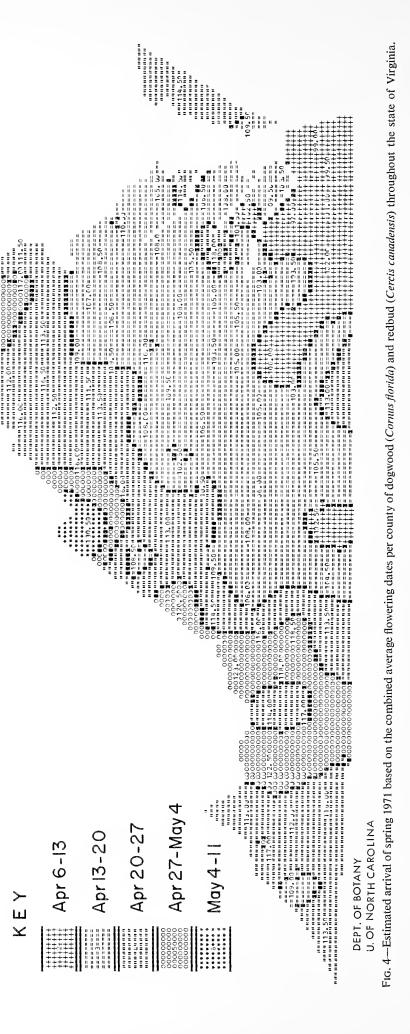
B. Flowering Date

= (.0056) (elevation in feet) + 102.88

The two equations each come closer to predicting the actual flowering dates within the northern and southern portions of the state respectively than when one equation is used for the entire state. A statistic (correlation coefficients), which will become even more meaningful with additional data and environmental parameters, proved interesting already with our limited data pool.

Correlation coefficient* Flowering date vs. altitude counties north of 37°30' N .55 counties south of 37°30' N .84

^{* (}value of 1.0 would indicate perfect correlation)



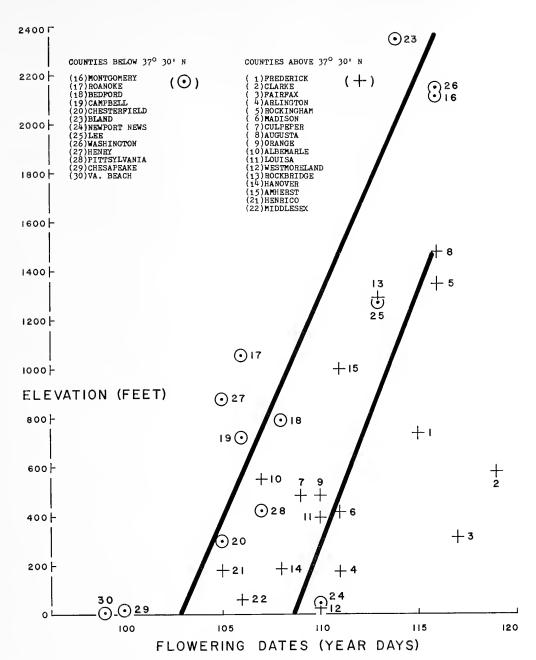


Fig. 5—Results of two linear regression equations, expressing graphically the relationship between combined average flowering date of dogwood-redbud and elevation, based on the average county flowering dates reported in 1971.

The very high correlation between the two parameters in the southern counties could be a reflection of a greater range of values (from east to west across the state) in the south than in the north, at least for the counties that provided enough data for these analyses.

You may also be interested in knowing that our Virginia data have already been used as an integral part of a phenology map for the entire eastern United States. Even though North Carolina has two years of data to our one, we already have the same quantity they do. The difference between Dogwood and Redbud combined average flowering dates and Lilac flowering dates for three West Virginia locations and

one in Pennsylvania, has been reported by other researchers as being only 2 to 5 days. With the above information the North Carolina Phenology team plotted New England lilac flowering data along with Dogwood-Redbud data from North Carolina and Virginia and limited data from Florida, Alabama, Georgia, Tennessee, Kentucky, Mississippi, South Carolina, West Virginia, Ohio, Indiana, and Pennsylvania to produce an eastern United States spring phenology map. The more we know about the accuracy and reliability of data from our Virginia and North Carolina intensive studies, the more we can use widespread small amounts of data to give us a broader picture and understanding of what

is happening when with the seasons. By acquiring all these quantitative data our goal as ecologists is to be better able to understand what is happening naturally in our biome area, therefore making it possible to more effectively manage our natural resources by gearing man and his activities toward a closer dynamic balance with his surrounding ecosystems.

If you are among those who previously submitted completed response forms, or have already indicated an interest in helping, you are on the mailing list and will be receiving seasonal forms for future use. If you have not as yet participated in my program, I would very much appreciate your help by, 1) com-

pleting and returning response forms you may already have, 2) sending me your name and address, 3) telling friends and neighbors who also can help to broaden our data pool. Those already helping should also try to spread the word. I will be happy to furnish as many response forms as you require, with instructions for observations, or you can duplicate the forms. We must collect data from all counties, and as many different localities within them, as possible. You do not have to restrict yourself to the locality nearest you, as long as you can collect reliable information.

Communications and Reports

VIRGINIA ACADEMY OF SCIENCE

Summary of Council Meeting* November 7, 1971

Council was convened at 10:30 A.M. in Newcomb Hall on the campus of the University of Virginia, President Turner presiding. Minutes of the Council Meeting of May 14, 1971, were read and approved. President Turner informed Council of past problems involved with the academy's aecounting firm (see minutes of the Executive Committee meeting of September 26, 1971). President Turner represented the Academy at the inauguration of the new President of the University of Richmond. Members of the Aeademy have received an invitation, by way of President Turner, to attend the coming annual meeting of the West Virginia Academy of Science. The President also notified Council of his plans to revamp and revitalize the relations of the Academy with the state's Business Community.

Treasurer's Report

Mr. Grigg informed Council concerning the Executive Committee's action in closing the checking account of the Virginia Museum of Science Committee and opening an account in the name of the Committee on Conservation and Natural Resources (see minutes of the Executive Committee, September 26, 1971).

Awards Committee

There was no report. President Turner requested the chairman of this Committee to initiate a thorough study regarding the procedures involved in the nomination and election of Fellows.

Constitution and Bylaws Committee

Mr. Midyette, Chairman, reported that the new Constitution and Bylaws, approved by the Academy, have been published in the *Virginia Journal of Science* (22, 21, 1971). In accordance with the new Bylaws President Turner appointed Mr. Midyette to serve as parliamentarian until May 5, 1972.

Finance Committee

The Chairman of the Finance Committee was unable to attend. A tentative budget was submitted, however, with the understanding that an official budget would be presented to the Executive Council on December 10, 1971. After some discussion President Turner ruled that Council had to approve the 1972 budget; approval by the Executive Committee was not sufficient. Mr. Paul Siegel moved that until the next Council Meeting the Academy should operate at a level commensurate with the budget of 1971. This motion was seconded by Mr. E. L. Wisman. After a lengthy discussion a substitute motion was offered by Mr. E. S. Harlow and seconded by Mr. J. Midyette. Mr. Harlow moved that the

budget prepared by the Finance Committee meeting on November 29, 1971, be presented to the Executive Council which in turn will canvass the members of Council and, if this budget is approved by Council it will be in effect until the Council Meeting in March, 1972. Motion passed with no dissenting votes.

Virginia Junior Academy of Science

Mr. Wisman reported that the next V.J.A.S. meeting in Lexington will follow the same format as the previous meeting. Mr. Wisman also informed Council of possible financial problems in coming years due to a reduction of funds from N.S.F. This information led to a general discussion of the financial condition of the Academy and resulted in a recommendation from Council that the budget requested by V.J.A.S. for 1972 not be reduced.

Long Range Planning

Mr. Ulrich reported that the committee is studying the involvement of Junior and Community College scientists in the Academy. The committee is also interested in finding feasible means to accumulate, store, and quickly retrieve basic data regarding membership, attendance at meetings, etc.

Membership Committee

A written report of this committee is attached to the official minutes. In general, the committee will attempt to canvass all institutions of higher learning in the state for potential candidates for membership.

Research Committee

Mr. Flint recommended to Council the following guide-lines:

- a) Grant requests will be acted upon on three dates during a year—January 15, April 15, and September 15.
- b) A grant request must be approved by an official of the applicant's institution (for example—Head of Department, Dean of Faculty).
- c) A written report upon completion of the research shall be required from each recipient.
- d) The grant request must contain a reasonably detailed budget.

Following Mr. Flint's report, Mr. Carpenter moved and Mr. Midyette seconded that Council authorize the Research Committee to implement the above described guide-lines in regard to research grant requests. These guide-lines are to be published in the Journal of the Virginia Academy of Science.

As of January 1, 1972, Mr. Flint will resign from the Research Committee and President Turner will appoint someone to fill Mr. Flint's unfinished term. President Turner will designate Mr. N. F. Murphy as Chairman and if Mr. Murphy is not able to serve in this capacity the President will appoint an Acting Chairman.

^{*} Abbreviated by the Editor from minutes provided by the Secretary, Garnett R. Brooks, Jr.

Finance and Endowment

Mr. B. Bruner has suggested (Executive Meeting Minutes, September 26, 1971), that the fee charged for the audit of trust funds be paid from the trust funds instead of from the general fund of the Academy. Mr. Midyette moved and Mr. Ulrich seconded that this suggestion be studied by the Finance and Endowment Committee. Motion passed without dissent.

Conservation and Natural Resources

Mr. Hughes reported that the subject of their next committee meeting will be "the problems concerning the wetlands of Virginia."

Virginia Museum of Science

A written report of the Ad Hoc Committee on the Virginia Museum of Science is attached to the official minutes. Mr. Carpenter moved and Mr. Harlow seconded that Council accept the first recommendation of the Ad Hoc Committee. After much discussion this motion was withdrawn by its sponsors. Mr. Bradley then moved and Mr. Clarke seconded that "The Museum of Science Committee recommends that the V.A.S. Council reaffirm its support of the Virginia Science Museum and that V.A.S. members be encouraged to support the Museum in whatever ways are appropriate." This motion passed unanimously. Mr. Hughes then moved and Mr. Grigg seconded that a letter informing the Board of Trustees of the Virginia Museum of Science of the above motion be sent to the Board's Chairman. Motion passed unanimously.

Mr. Carpenter moved and Mr. Bradley seconded that Council accept the second recommendation of the Ad Hoc Committee. Mr. Siegel moved to amend the motion by deleting the words "fifteen minutes"; Mr. Ragone seconded. Motion to amend was passed. The amended motion was passed unanimously and

reads as follows:

The Museum of Science Committee recommends that each section of the Academy be encouraged to have a paper at the May 1972 meeting designed to:

- a) inform all of its section members about the Museum plan and its connection with that particular section,
- b) solicit the formation of advisory groups from individual sections to assist the museum board in planning appropriate exhibits, areas, and activities in each of the Academy's areas of expertise.

Mr. Carpenter moved and Mr. Morrow seconded that Council accept the third recommendation of the Ad Hoc Committee. Motion passed with three dissenting votes and reads as follows:

The Museum of Science Committee recommends that Council authorize the Executive Committee to approve the expenditure of a portion of the Museum Fund which remains (about \$1270) for

preparation and printing of an informational packet on the museum to be distributed by the Academy to various Academy members, women's groups, and other possible supporters or benefactors of the museum.

Local Arrangements Committee

Mr. Carpenter reported that a tentative program for both the V.A.S. and V.J.A.S. had been arranged and that preparations for the coming meeting were progressing nicely. Mr. Midyette moved and Mr. Clarke seconded that the Executive Committee be authorized to provide sufficient funds for the use of the Local Arrangements Committee in preparation for the annual meeting in Lexington. Motion passed unanimously.

Registration Fee

Mr. Midyette moved and Mr. Whitehead seconded that Council accept the recommendation from the Executive Committee that the standard registration fee for the 1972 meeting be set at \$4.00 and the preregistration fee be set at \$3.00. Motion passed unanimously.

Visiting Scientists

Mr. Clarke released a list of scientists who have volunteered their services to high schools (a copy is attached to the official minutes).

Section Report—Geology

Geology section members recently held a Virginia Field Conference in association with interested High School teachers. One of the highlights of this meeting was a visit to Nelson County to inspect the flood areas.

Non-Commercial Exhibitors

Mr. Siegel moved and Mr. Whitehead seconded that Council accept the recommendation from the Executive Committee allowing non-commercial institutions to exhibit at the annual meeting for a fee of \$50.00. Motion passed without dissent.

New Business

In response to a request from Mr. L. Morrow, Mr. Carpenter moved and Mr. Midyette seconded that "Mr. Morrow is hereby granted permission by Council to extract selected material from *The James River Basin* (under copyright to the Virginia Academy of Science) to be distributed with no fee by the Math-Science Center." Motion passed unanimously.

The date for the next Council Meeting was set for March, 1972, in Charlottesville, Virginia.

Notice of Death

Mr. John Mahan of Lynchburg College died on Oetober 31, 1971.

VIRGINIA ACADEMY OF SCIENCE OFFICERS, MEMBERS OF COUNCIL, COMMITTEES—1971–72

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VIRGINIA ACADEMY OF SCIENCE	Margaret Hess
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*Ivey F. Lewis	R. G. Henderson
*James Lewis Howe	S. G. Bedell
*Robert E. Loving	M. J. Murray and Forrest F. Cleveland 1939
*J. Shelton Horsley	Walton C. Gregory1940
*Donald W. Davis	Charles Ray1941
*William Mosley Brown1928–29	No Award
*Garnett Ryland	J. B. Meyer
*L. G. Hoxton	J. Herbert Taylor1944
I. D. Wilson	No Award1945
*T. McN. Simpson, Jr	Boyd Harshbarger
*William A. Kepner	D. B. DeLury
William T. Sanger	Henry Leidheiser, Jr
Ida Sitler	Walter S. Flory
*H. E. Jordan	Erling S. Hegre
D. Maurice Allan	D. B. Duncan
*Earl B. Norris	D. R. H. Gourley
Ruskin S. Freer	Stephan Berko and Frank L. Herford 1953
*Wortley F. Rudd	Lynn D. Abbott, Jr., and Mary J. Dodson 1954
George W. Jeffers	Albert W. Lutz, Jr., and E. B. Reid1955
*Marcellus H. Stow	M. C. K. Tweedie
*W. Catesby Jones	R. A. Bradley, D. E. W. Schumann, and
Robert F. Smart	Walter H. Lewis
H. Rupert Hanmer	G. Tyler Miller, Jr., and R. K. Lawless 1958
*Arthur Bevan	Dorothy L. Crandall
Jesse W. Beams	Lawrence I. Miller
*Sidney S. Negus	Irving R. King, Billy W. Sloope, and
Boyd Harshbarger1949–50	Calvin O. Tiller
*Guy W. Horsley	Claude P. Talley and G. R. Taylor, Jr 1962
Paul Patterson	H. A. David
Lloyd C. Bird	E. Rae Harcum1964
*Allan T. Gwathmey1953–54	Doris Kuhlmann-Wilsdorf
Irving G. Foster	Frank A. Vingiello1966
Walter S. Flory, Jr	O. R. Rodig and Galal Zanati1967
E. S. Harlow	H. H. Hobbs, P. C. Holt, and
*William G. Guy	Margaret Walton
John C. Forbes	A. J. McCaffery, P. N. Schatz, and
William M. Hinton	T. E. Lester
Wilson B. Bell	I. Gordon Fels
Horton H. Hobbs, Jr	L. R. Durden, L. H. Slack, and
Jackson J. Taylor	P. R. Eusner
*Foley F. Smith1963–64	JEFFERSON MEDAL WINNERS
S. S. Obenshain	RECIPIENTS OF
Roscoe D. Hughes	THE JEFFERSON GOLD MEDAL
Stanley B. Williams	
James W. Cole, Jr	Alfred Chanutin
Paul B. Siegel1968–69	William B. Porter
D. Rae Carpenter, Jr	H. M. Phillips
Maurice B. Rowe	G. M. Shear and H. D. Ussery
Edward F. Turner, Jr 1971–72	RECIPIENTS OF
*Deceased	THE JEFFERSON PRIZE
RECIPIENTS OF	L. G. Overholzer and J. H. Yoe 1940
J. SHELTON HORSLEY	Allan T. Gwathmey
RESEARCH AWARD	R. N. Jefferson
Carl C. Speidel	W. H. Hough
John H. Yoe	Clinton B. Cosby
J. C. Strect1929	
H. E. Jordan and Carl C. Speidel 1930	RECIPIENTS OF
E. C. Stevenson	VIRGINIA ACADEMY OF SCIENCE
James H. Smith1932	MERITORIOUS SERVICE AWARDS
S. A. Wingard	Dr. Ivey F. Lewis
E. P. Johnson	Dr. William T. Sanger1956

The American Tobacco Company
Research Laboratory
Dr. Lloyd C. Bird
Dr. Allan T. Gwathmey
Dr. Sidney S. Negus
Dr. Jesse W. Beams

The name of the award was changed in 1965 to the Virginia Academy of Science, Ivey F. Lewis Distinguished Service Award.

Dr. Boyd Harshbarger196	6
Dr. Russell J. Rowlett, Jr	7
Dr. George W. Jeffers	
Dr. Walter F. Flory, Jr	9
Dr. Roscoe D. Hughes	0
Dr. Horton H. Hobbs, Jr197	1

No awards in 1957, 1960, 1961, 1962 and 1964.

FELLOWS OF THE VIRGINIA ACADEMY OF SCIENCE

Jesse Wakefield Beams, University of Virginia Robert Clifton Carter, Virginia Polytechnic Institute John Campbell Forbes, Medical College of Virginia Thomas E. Gilmer, Hampden-Sydney College Edward S. Harlow, The American Tobacco Com-

pany, Virginia Branch
W. T. Harnsberger, Jr., Madison College
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S. M. Heflin, 508 Highland Road, Lexington, Vir-

ginia 24450

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Harry G. M. Jobson, Bridgewater College Clyde Young Kramer, Virginia Polytechnic Institute J. Douglas Reid, Medical College of Virginia William T. Sanger, Medical College of Virginia E. L. Wisman, Virginia Polytechnic Institute

News and Notes

VIRGINIA ACADEMY OF SCIENCE

1972 Meeting

Virginia Military Institute Washington and Lee University Lexington, Va. May 2-5, 1972

1973 Meeting

50th Anniversary College of William and Mary Williamsburg, Va. May 1–4, 1973

1974 Meeting

Old Dominion University Virginia Wesleyan College Virginia State College Norfolk, Virginia April 30-May 4, 1974

1975 Meeting

Madison College Harrisonburg, Va. May 6–9, 1975

MOUNTAIN LAKE SUMMER SESSION

The University of Virginia has announced that eight graduate courses emphasizing environmental biology will be offered at the Mountain Lake Biological Station this summer. They are as follows:

First Term: June 14–July 18

Aquatic Ecology: Dr. George M. Simmons, Jr., Virginia Polytechnic Institute

Algology: Dr. Francis R. Trainor, University of Connecticut

Herpetology: Dr. H. G. M. Jopson, Bridgewater College

Invertebrate Zoology: Dr. Fred Diehl, University of Virginia

Second Term: July 19-August 22

Ecological Genetics: Dr. David West, Virginia Polytechnic Institute

Pteridology: Dr. Warren H. Wagner, University of Michigan

Taxonomy of Secd Plants: Dr. Carl S. Keener, Pennsylvania State University

Mammalogy: Dr. Charles O. Handley, United States National Museum

The Ivey F. Lewis Fellowship, an annual award of \$150, is made by the Phipps and Bird Company of Richmond to a student undertaking research or graduate training at the Station. Fellowships of \$150 for one student in each term have been made available by the North Carolina Botanical Garden. This fellowship may not be held concurrently with any other stipend from the Station. The recipients of these awards are chosen by the Research and Awards Committee of the Department of Biology. Application for awards should be sent to the Director,

Mountain Lake Biological Station, University of Virginia, Gilmer Hall, Charlottesville, Virginia 22903.

WEST VIRGINIA ACADEMY OF SCIENCE

Dr. Earl L. Core, President of the West Virginia Academy of Science has issued an invitation to the members of the Virginia Academy of Science to attend and participate in the annual meeting of the West Virginia Academy in Bluefield on April 7, 1972. Dr. Elvis Stahr, President of the National Audubon Society, will speak at their meeting. Dr. Core also extends an invitation to our members to submit papers at that meeting. If you would like to avail yourself of this opportunity, write Earl L. Core, Department of Biology, West Virginia University, Morgantown, West Virginia 26506.

POLLUTION PUBLICATIONS

Tejinder S. Sibia, Science Librarian at VPISU, has compiled a selected list of publications on pollution available in the Carol M. Newman Library at the Virginia Polytechnic Institute and State University. The purpose of the list is to create interest in the area of pollution and to give some indication of the types of publications relevant to the subject. It is planned to expand and improve the list in the future. Mr. Sibia will be glad to circulate the list free as long as the supply lasts.

VEPCO POLLUTION CONTROL

The Virginia Electric and Power Company has been named one of three finalists in the annual Gold Medal Awards program for water pollution control presented by the Sports Foundation, Inc. Winners to be chosen from this list of finalists in the two divisions will be announced at the presentation ceremonies on Monday, February 14, at McCormick Place, in Chicago.

There were 120 entries from across the nation in

the contest.

Finalists in the Water Pollution Control single clant program were Armstrong Cork Co., Macon, Georgia; U. S. Gypsum Co., Gypsum, Ohio; and

The Gold Medal Awards in water pollution control were established in 1968. The awards are made annually to members of American industry which have made outstanding achievements in pollution control. Judges for this year are nationally recognized leaders in this field and in the environmental sciences. They include Dr. Charles B. Wurtz, chairman, consulting biologist, Philadelphia, Pennsylvania; Earl C. Hubbard, assistant director of North Carolina Department of Water & Air Resources, Raleigh, North Carolina; and Roy F. Weston, president of Roy F. Weston Environmental Scientists and Engineers, West Chester, Pennsylvania.

Vepco's entry described a set of power spray modules in the discharge canal of the company's Chesterfield Power Station which reduces the temperature of the plant's cooling water before it is returned to the James River. The Chesterfield operation is the first such full-scale installation of the innovative water cooling system, and was installed at a cost of over \$2 million.

BLACKWATER CREEK PROJECT

Last summer was an important one for Randolph-Maeon Woman's College students who participated in a National Science Foundation Student-Originated Studies Program in a project earried out in Lynchburg's Blackwater Creek area where a prospective park may be located.

A comprehensive 153-page report resulting from the summer project presents conclusions generally favoring the establishment of a park in the Blackwater Creek area. Flora and fauna surveys revealed unusual diversity for such a small area of typical Piedmont terrain, though the soil is of poor quality and unsuited for commercial development. Water analysis and microbiology teams concurred that

Blackwater Creek is marginally polluted mainly from a deficient, but repairable sewer system.

The sociology team favored the installation of the park and approved the facilities as proposed by the eity planning office, which they concluded will be acceptable to a majority of Lynchburg's population.

The team of students from R-MWC who conducted the ecological study of Blackwater Creek Basin were awarded a grant of \$16,760 from the N.S.F. to earry out research over a twelve week period. Dr. Franklin F. Flint, R-M professor of biology, was faculty project advisor for the research survey.

The environmental research study was earried out in ecoperation with the Lynchburg Planning Commission. Student project director was Anne Lindsey from Bluefield, Va.; and her assistant was Barbara Laning from Akron, Ohio. They, together with Ellen Suthers, from Roanoke, Va., presented a report on the project at a National Science Foundation Student-Originated Studies Program meeting in Philaceiphia December 28–29, 1971.

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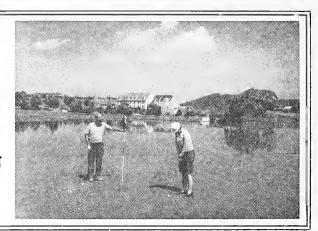
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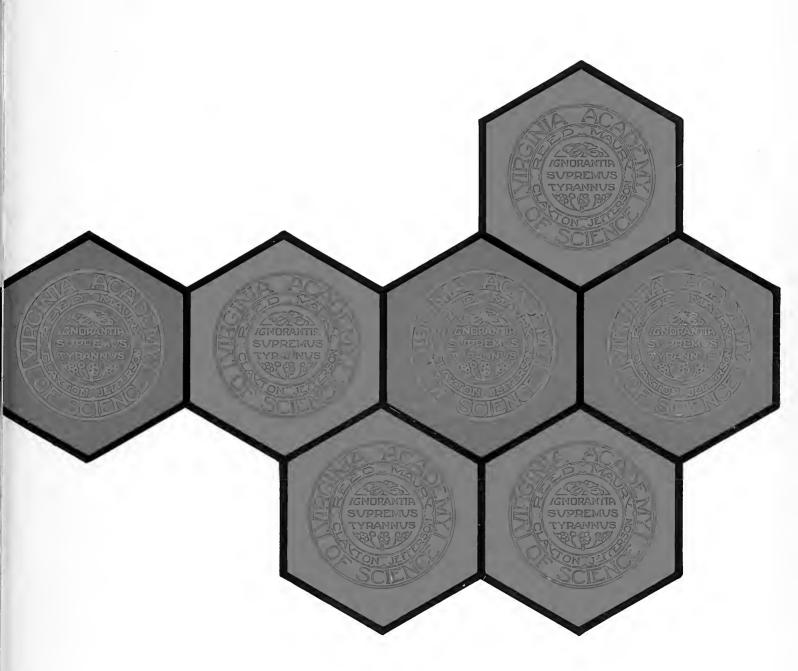
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SUMMER 1972 VOL.23, NO.2



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THE VIRGINIA JOURNAL OF SCIENCE

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Back issues are available for some years at \$3.00 per issue plus postage.

The front cover is by Douglas C. Hensley.

Department of Biology College of William and Mary Williamsburg, Virginia 23185 Received January 10, 1972

The Effects of Oil on the Gill Filtration Rate of Mya arenaria

Abstract—The acute effects of oil pollution on the soft-shelled clam, Mya arenaria, were studied by measuring changes in turbidity of graphite-particle suspensions as indices of filtration rates. Filtration rates were measured during three-hour intervals before and after exposure to either 0.9 per cent oil-water emulsions or to 0.9 per cent extracts of oil in water. A paired observations test indicated significant rate increases in clams exposed to the emulsions, but there were no definite trends in the responses of clams exposed to the oil extract.

Introduction

Oil pollution of coastal areas was recognized as a serious problem in the United States more than fifty years ago (1). Despite estimated annual spillage of one million metric tons in coastal areas and in shipping lanes (2), surprisingly few studies have been made on the environmental effects of oil. Recently Blumer, Sanders, Grassle, and Hampson (2) reported on a long-term study of a small oil spill (650–700,000 liters) that occurred near Woods Hole, Massachusetts. Three months after the spill detectable concentrations of the oil were found in sediments fourteen meters below the water surface, and 10 months later the contaminated sediment covered 10 times the area initially affected. Persistent oil residues were detected in the flesh of shellfish taken from the polluted area. Both the chronic and acute effects of the oil residues on lamellibranch physiology are still largely unknown. A few studies using variously measured bivalve filtration rates as physiological indices have been made (3–5). Using a procedure adapted from Jorgensen (6), this worker has attempted to assess the acute effects of oil pollution on quantitative aspects of gill filtration by the soft-shelled clam, Mya arenaria.

Materials and Methods

M. arenaria were collected in mid-March and in early May at Sandy Point on the York River. A minimum of 6 days was allowed for acclimation to the salinity and temperature of the laboratory aquarium (25.8 % at 20 °C).

All experiments were performed at 20 °C, using filtered natural sea water (salinity 24.4 %) and suspensions of Aquadag (particle diameter 1–2.5 μ)

from the Acheson Colloids Corporation. Changes in turbidity, as the animal removed suspended particles by filtration, were determined with a Bausch and Lomb Spectronic 20 colorimeter set at 500 m μ . Number Six Bunker C fuel oil, either whole or in extract, was prepared in 10% (v/v) concentrations. In one series of tests, the water-soluble fractions of oil were extracted during a minimum of 8 hours' agitation. The aqueous portion was allowed to separate overnight and was filtered before use. Another group of clams was exposed to the same quantity of emulsified oil, which was agitated for 4 hours before use.

Each clam was placed in one liter of water under constant aeration. When their siphons had been open for 5–10 minutes, approximately 2 ml of a recently prepared, 4% (w/v) Aquadag suspension was added, and the first transmittance reading was taken. Initial concentrations transmitted 14.5–26.5%. Readings were made subsequently every 30 minutes for 3 hours. At this point 100 ml of oil or oil extract plus an additional 0.2 ml Aquadag were added. The emulsified oil was given to a group of 10 clams, and the oil extract was given to another group of 15. Transmittance was measured again at 30 minute intervals for a minimum of 3 hours. Occasionally it was necessary to add more Aquadag during this period.

Filtration rates were calculated for each 30 minute interval using the equation given by Welsh, Smith, and Kammer (7). In all cases, corrections were made for changes in turbidity due to settling and clumping of particles as measured in a control vessel containing no clam. Mean filtration rates for the periods before and after oil (or extract) addition were then calculated. Values for intervals following the addition of Aquadag and values for intervals during which transmittance changed 1% or less were not considered. Presumably no change in transmittance reflects the normal periodic pauses in generation of ciliary currents, which were no more frequent after the addition of oil than before. Previous experimentation determined transmittance readings to be accurate to $\pm 0.5\%$. Paired observation tests compared changes in mean filtration rates for the group which received the emulsified oil and for the group which received only the oil extract. Ninety-five per cent

^{*} Present address: Department of Zoology, Duke University, Durham, North Carolina 27706.

TABLE I Mean Filtration Values^a

Clams Receiving 0.9% Oil Extract				
M_{1}^{b}	SD	M_2^c	SD	$\frac{M_2 - M_1}{M_1}$ (%)
208	81	235	133	1.2
251	218	169	119	-32.6
94	65	68	26	-28.0
131	68	108	62	-17.6
137	117	60	24	-56.0
457	332	422	124	-7.6
435	356	273	268	-37.2
511	132	698	197	34.5
186	85	445	149	139.0
126	58	244	138	93.6
791	257	228	98	-71.2
201	30	250	155	24.4
544	305	783	24	43.9
290	66	423	250	45.9
523	322	314	94	-40.0

Clams Receiving 0.9% Oil Emulsion

M_1^b	SD	M_2^c	SD	$\frac{M_2 - M_1}{M_1}$ (%)
433	171	653	133	50.8
210	103	960	586	357.0
703	424	911	296	29.6
337	214	600	281	78.0
1100	183	739	444	-32.8
477	357	503	91	5.4
517	156	866	419	67.5
397	106	824	906	108.0
466	327	1260	971	170.0
278	162	1052	982	2.8

^a Clams 41-61 mm in length

 b M_{1} = filtration rate in ml/hr before addition of oil or

° M₂ = filtration rate in ml/hr after addition of oil or extract

confidence intervals around the mean per cent changes in filtration rate were also determined for both groups, and for a companion experiment which included other oil types and other concentrations.

Results

In the group given oil extract, 8 of 15 clams showed rate decreases, six showed rate increases, and one showed almost no change. These changes were not significant. On the other hand, significant changes (p < 0.02) in filtration rates did occur in clams subjected to the same concentration of emulsified oil. In fact, 9 of 10 clams increased their rates (Table I). Significant rate increases also occurred in the companion experiment (Table II).

Discussion and Conclusions

Chipman and Galtsoff (4) reported a strong depression in filtration rates of Crassostrea virginica following the addition of aqueous, crude oil extracts

TABLE II Changes in Filtration Rate: Confidence Limits

Oil Types	No. Clams	95% Co D*	nfidence Max. D	Limits Min. D
SAE 30 & Bunker C,				
0.5–1.0%	6	194.0	354.0	33.5
Bunker C, 0.9% Extract	15	6.2	38.1	-25.8
Bunker C, 0.9% Emulsion	10	111.0	199.0	23.0

* D is the mean % change in filtration rate, $M_2 - M_1$

in comparable concentrations. In the present experiment, M. arenaria did not respond similarly, perhaps because the light, toxic fractions were removed from the Bunker C oil during the refining process (8).

Among the experimental animals, filtration rates varied considerably from one 30 minute interval to the next. Other workers (6) have also reported large fluctuations in filtration rates. During fifteen minutes of observation, one clam in a graphite-free container closed its siphons for several minutes at a time, perhaps in response to external stimuli such as low frequency vibrations or changes in light intensity. Despite variation, increases in gill filtration rates have been detected. Further, the somewhat surprising increases were not caused by water-soluable oil fractions, but by particles of the oil itself. Under natural conditions, large quantities of oil, emulsified by the action of wind and waves, certainly might enter the habitat of M. arenaria during an oil spill. Indeed, Blumer, Souza, and Sass (9) found oil particles distributed to 10 meter depths following gale conditions in an area covered by an oil slick. M. arenaria in oil polluted areas would thus be likely to ingest

considerable quantities of oil.

The physiological stimulus of increased gill filtration cannot be identified at present, but the constant aeration must have insured that the response was not ventilatory in nature. How ingested oil affects most aspects of lamellibranch physiology is still largely unknown. Petroleum hydrocarbons, as well as some biosynthesized ones, are metabolized very slowly (9), and they would be more likely to cause physiological changes in organisms that increase their ingestion rates during the initial period of oil pollution. The potential for long-term damage to shellfish beds in polluted areas clearly exists. Crassostrea virginica kept in unpolluted water for six months following exposure to oil showed no decrease in the concentration of petroleum residues in their tissues. Juvenile blue mussels (Mytilus edulis) from the same area failed to mature sexually (2). Unfortunately, the potential effects are further complicated by synergisms. Hartung and Klinger (10) found that oil dispersed in sediments concentrated waterinsoluble DDT by a factor of one million. Organisms that ingest oil are also likely to acquire large pesticide loads. Oil pollution thus is a threat to the

biosphere, both due to its own toxic constituents and because of the other organic compounds that it concentrates. Clearly, more research to determine the biological effects of oil pollution is needed.

Acknowledgements

I am deeply indebted to Dr. Charlotte P. Mangum for her encouragement and guidance during the period of experimentation and during the preparation of the manuscript.

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Miles F. Johnson

Department of Biology General Academic Division Virginia Commonwealth University Richmond, Virginia 23220 Received January 27, 1972

Eupatorieae (Asteraceae) in Virginia: Eupatoriadelphus, Ageratina, Fleischmannia and Conoclinium.

Abstract—A key to the genera Eupatoriadelphus, Ageratina, Conoclinium and Fleischmannia is presented as well as keys to species and varieties. Brief genus and species descriptions, ecological data, flowering and fruiting dates and distribution maps for each species are given. Known chromosome numbers are included.

Introduction

This paper is the third in a series dealing with the floristics of the Virginia Eupatorieae (Asteraceae). Liatris, Carphephorus, Mikania and Kuhnia have been considered in previous papers (1, 2). Eupatoriadelphus, Ageratina, Fleischmannia and Conoclinium are dealt with here. Eupatorium remains to be treated as a unit.

This study is based upon collections found in herbaria of the following institutions: Longwood College, Farmville, Lynchburg College, Lynchburg, Old Dominion University, Norfolk, Virginia Commonwealth University, Richmond, Virginia Polytechnic Institute and State University, Blacksburg¹, Virginia Military Institute, Lexington, University of North Carolina, Chapel Hill, United States National Herbarium, Washington, D. C., the Gray Herbarium, Cambridge, Mass., and the New York Botanical Garden, The Bronx, New York. I gratefully acknowledge the assistance given by the curator and/or director of the herbarium at each institution for allowing me to study the collections. Travel funds were provided by the Virginia Academy of Science and Virginia Commonwealth University.

Approximately 500 specimens have been examined and nearly all taxa have been observed in the field in Virginia and elsewhere. The collections made by the author during this study are deposited in the herbarium at Virginia Commonwealth University.

Dots on the maps indicate exact locations; closed triangles indicate a collection from that county without specific location data. Open circles are used to indicate collections cited in literature though not all specimens have been seen personally.

Nomenclature follows King and Robinson (3–6) and descriptions generally follow those of Radford,

1 Not all specimens cited by Massey (14) are at the VPISU Herbarium; his citations without vouchers are indicated in the body of the paper.

Ahles and Bell (7), Fernald (8), and Gleason and Cronquist (9).

Taxonomic Treatment

The Eupatorieae has been characterized previously (2) in this series.

Key to Genera

Leaves lanceolate, elliptic to ovate, in whorls of 3–6; involucral bracts purple to cream in successively shorter series 1. Eupatoriadelphus. Leaves ovate to deltoid, opposite, if whorled, not lanceolate; involucral bracts scarious or green,

subequal.

1. Eupatoriadelphus King & Robinson. Joe-Pye Weed; Purple Boneset.

Perennial herbs. Leaves verticillate, narrowly lanccolate, elliptic to ovate, all cauline. Heads cylindric, in dense to open corymbs. Involucral bracts unequal, multiseriate, imbricate. Flowers tubular, perfect, the corolla of varying shades of pink to purple, bearing stomata on backs of corolla lobes. Achenes 5-ribbed, prismatic, glandular-atomiferous,

with a rather distinct carpopodium. Pappus capillary. Eupatoriadelphus is a new genus described by King and Robinson (6) to include four verticillateleaved species of the northeastern United States previously considered under Eupatorium s. 1. In addition to the readily recognized leaf arrangement, the flowers possess stomata on the backs of the lobes, a character not known in Eupatorium s. s. (6, 10).

The distinctiveness of these species has been recognized previously by DeCandolle under Section *Verticillata* of *Eupatorium* and by Wiegand and Weatherby (11) who treated these species as a unit.

The combination of characters listed above is unique and thus the new genus is considered to be

distinct from Eupatorium and part of the Virginia Flora.

The species can be distinguished with the follow-

ing key:

- - 2. Flowers 8–15 (–24) per head; corymb flat-topped; rare in western Virginia..... 2. E. maculatus.
 - - 3. Stems hollow, purple throughout..... 4. *E. fistulosus*.
- Eupatoriadelphus dubius (Willd. ex Poir.) King & Robinson. Joe-Pye Weed.

Eupatorium dubium Willd. ex Poir.

Perennials to 8.5 dm tall; stems solid, speckled with purple; leaves firm, in whorls of 3, less commonly 4, ovate to lanceovate, 6–10 (–18) cm long, 2.5–6.5 (–9) cm wide, coarsely serrate, conspicuously triplinerved and atomiferous-glandular beneath; corymbs dense, convex, heads 5–6 flowered, involucre cylindric, 8–9 mm high, the corolla purple, 4.5–6 mm long, pappus (4–) 5–6 mm long. 2n = 20 (12).

Relatively common on the Coastal Plain in acid soils of marshes, sphagnous bogs, sandy peat and roadside ditches (Fig. 1) closely parallelling the distribution of sand and clay soils (13). Massey (14) shows the species from Accomack and Greene Coun-

ties but I have not seen the specimens. The determination from Greene County is questionable as this is far out of the range of *E. dubius* in Virginia.

The total range of the species extends from Maine to South Carolina in the Coastal Plain (8,9) and in the Piedmont of North and South Carolina (7). This species is in flower and fruit in September and October but rarely earlier in the summer.

Eupatoriadelphus dubius is distinguished in the genus by the short, rather thick leaves with the conspicuous lower pair of veins and the abundant minute "atoms" on the lower surface. This is also the only species of Eupatoriadelphus restricted to the Coastal Plain.

Fernald (8) includes forma *elutum* Fern. to designate those plants with very pale corollas. This form is not known from Virginia.

2. Eupatoriadelphus maculatus (L.) King & Robinson. Joe-Pye Weed.

Eupatorium maculatum L.

Similar to *E. dubius*, but usually taller, with subsessile to short petiolate, pinnately veined, lanceolate leaves; heads of 8-15 (-24) flowers in dense, flat-topped corymbiform clusters. 2n = 20 (12).

A northern species, extending south to Maryland (9) and to North Carolina in the mountains (7, 8) is known from a single collection from Augusta County: Summit of Elliott Knob, *H. A. Allard 3255* (US), July 18, 1937, generally in bud with few mature fruits. It is to be expected in the vicinity of Grayson County as *E. maculatus* is known from adjacent Ashe County, N. C. (7).

Massey (14) reports *E. maculatus* from Virginia Beach, Chesterfield County and a non-specific location in the Piedmont. I feel these determinations may have been confused with *E. dubius* which does occur

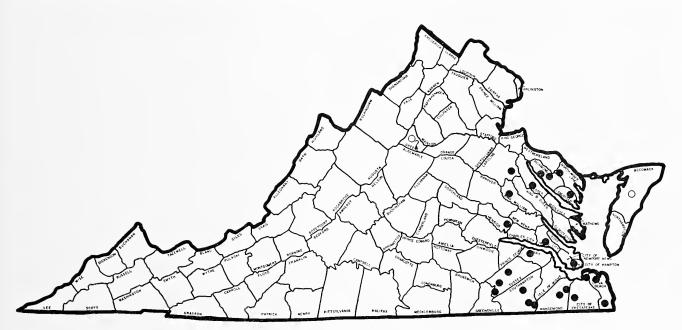


Fig. 1—Distribution of *Eupatoriadelphus dubius* in Virginia. Closed dots indicate exact locations; open circles indicate collections cited in literature though the specimens have not been seen personally.

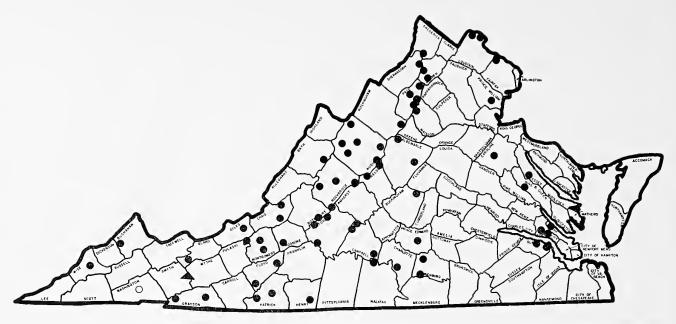


Fig. 2—Distribution of *Eupatoriadelphus purpureus* in Virginia. Closed dots indicate exact locations; open circles indicate collections cited in literature though the specimens have not been seen personally. Triangles indicate a collection from that county without specific location data.

on the Coastal Plain (see Fig. 1) and with which *E. maculatus* can be confused.

Eupatoriadelphus purpureus (L.) King & Robinson. Queen of the Mcadow; Gravel Root; Purple Boneset.

Eupatorium purpureum L.

Robust perennials 0.5–12 dm tall; stem solid, purplish at the nodes, at times spotted with purple at internodes; leaves in whorls of 3–5 (rarely opposite), lanceolate, ovate or elliptic, (10–) 12–27 (–40) cm long, (3.5–) 4–10 (–12.5) cm wide,

sharply serrate, rarely crenate, minutely glandularatomiferous beneath; corymb rounded, rather open, heads (4-) 5 flowered, involucres cylindrical, 7–8 mm high, corolla pale pink to violet, rarely whitish, 5–6 mm long, pappus (4.5-) 5–6.5 mm long. 2n = 20 (12, 15) 2n = 40 in Ontario (12).

Relatively common in the mountains, becoming more rare in the Piedmont and Coastal Plain, in shaded hardwoods, roadside banks, in shale, along streams and in other mesic habitats and at times associated with limestone (Fig. 2). Massey (14)



Fig. 3—Distribution of *Eupatoriadelphus fistulosus* in Virginia. Closed dots indicate exact locations; open circles indicate collections cited in literature though the specimens have not been seen personally. Triangles indicate a collection from that county but without specific location data.

reports this species from Amelia, Arlington, Fauquier, Hampton City, Henrico, Nansemond, Pulaski and Scott Counties. It is reported from Washington County (16) and from Tazewell County (17). Fosberg and Walker (18, 19) have collected E. purpureus in the Shenandoah National Park. The pattern of distribution is similar in the Carolinas (7).

The species range extends from southern New Hampshire to northern Florida and westerly to Minnesota, Nebraska and Oklahoma (8, 9). It is in flower and fruit in Virginia from (June-) mid-July through mid-Scptember with some fruits remaining on the plant into October.

Albino flowered plants are known (20) but none

has been seen in Virginia.

The dried root is reported to be astringent and the flowers to be diuretic when taken in hot water (21). Scherry (22) reports the flowers to be astringent also. This species is listed as a causative agent of hayfever in man (23).

Eupatoriadelphus purpureus is distinguished from E. fistulosus, which it closely resembles, by solid, shorter stems which are purple at the nodes and a

preference for drier habitats.

4. Eupatoriadelphus fistulosus (Barratt) King & Robinson. Queen of the Meadow; Joe-Pye Weed; Trumpet Weed.

Eupatorium fistulosum Barratt

Robust perennial to 30 (-45) dm tall; stems usually hollow, glaucous, usually purple throughout; leaves in whorls of 4–6 (–7), narrowly lanceolate to elliptic, (10–) 12–20 (–26) cm long, 3–6 (–9) cm wide, crenate to crenate-serrate, few glandular atoms or none; corymbs dense, rounded at the summit, heads 6-10 flowered, involucre cylindric, (5.5–) 6–7 mm high, corolla 4–5 mm long, bright pink-purple, pappus 4–5 mm long. 2n = 20 (12).

Common in the Piedmont and Mountains along

roadside ditches, in swales, along streams, in low woods and other moist habitats (Fig. 3), rarc on the Coastal Plain. Massey (14) reports this species from Giles, Fairfax, Princess Anne, Prince William and Sussex Counties though the specimens have not been seen by this author. Thorne and Cooperrider (24) also report this plant from Giles County. It is to be expected in the counties of Southwest Virginia. It is reported to be in every county in West Virginia (25). The total range extends from SW Quebec and Maine to Florida and west to the region of the Mississippi River (8). It is in bloom from (mid-) late July through August and in fruit from August through September.

Jennings (26) reports a white flowered plant from Pennsylvania though this forma is not known from

Virginia.

Eupatoriadelphus fistulosus most closely resembles E. purpureus but is distinguished by the usually hollow stem (small diameter stems and upper parts may be solid) and the more narrow leaves and an ecological preference for moist habitats.

2. Ageratina Spach

Perennial herbs. Leaves opposite, rarely whorled, ovate to deltoid, petiolate, margin dentate, serrate to subentire. Inflorescence corymbose, involucre of subimbricate, mostly subequal phyllaries. Flowers with a long slender tube and abruptly expanded limb; white. Achenes prismatic, 5-ribbed. Carpopodium distinct. Pappus of often deciduous slender, scabrous

The species included here have been considered to be in the genus *Eupatorium* until recently (4). Using detailed floral anatomy in combination with the narrow-stemmed corollas and deciduous setae, an assemblage of species are unquestionably recognized as Ageratina (4).

A New World genus of 4 subgenera and 196

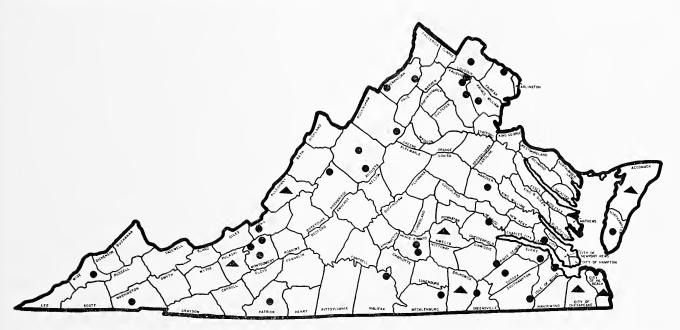


Fig. 4—Distribution of Ageratina aromatica in Virginia. Closed dots indicate exact locations; triangles indicate a collection from that county but without location data.

species (4), it is represented in the Virginia flora by two species of the Subgenus Ageratina distin-

guished in the following key.

1. Leaves somewhat thick and firm, the lower ones bearing 7–14 teeth per margin, petioles 0.3-1.5 (-2.0) cm long, corollas 3.75-4.25mm long......1. A. aromatica.

1. Leaves thin and submembranous, not firm, the lower ones bearing (11) 16–23 teeth per margin, pctioles 2.0-4.5 (-7.0) cm long corollas (2.2–) 3–4 (–4.5) mm long. .2. A. altissima.

1. Ageratina aromatica (L.) Spach

 $Eupatorium aromaticum {
m L.}$

Perennial herbs 5-9 (-10) dm tall; stems slender, usually glabrous; leaves thickish, lanceolate, ovate to deltoid, 3.5–8.0 cm long, (1.6–) 2.0–4.0 (–4.5) cm wide, margins crenate to serrate, rarely subentire, bearing from 7–14 (average of 10) teeth per margin, borne on petioles 0.3-1.5 (-2.0) cm long; corymbs open to dense, convex or flat-topped, heads 13–15 flowered, involucre cylindric when young, the bracts becoming more widespread in fruit, 3-5 mm high, the corolla white, 3.75–4.5 mm long; achene 2.5-3.5 (-5.0) mm long; pappus (3.0-) 3.5-4.0mm long. 2n = 34 (12, 27).

Generally scattered over the state (Fig. 4) in association with dry pine and oak woods, fields, sandy soil and disturbed woodlands, less common in mesic habitats. The total species range extends from Massachusetts in the north and continues in an arc along the Eastern seaboard to eastern Louisiana in the south and inland to Tennessee, Kentucky, West Virginia and southern Ohio (27). This species is in flower in Virginia from late August to early October and in fruit from late August to late October.

Ageratina aromatica closely resembles some species of Eupatorium but is readily distinguished by the infundibuliform corollas of Ageratina. It is distinguished, sometimes with difficulty, from Ageratina altissinia by the thicker leaves borne on short petioles as described in the key. Ageratina aromatica is also found in more dry habitats than is A. altissima.

Leaves are usually opposite in this species though Fernald and Long 11452 (US) from Sussex County and Lewis 1303 (VPI) from Amelia County show

leaves in whorls of three.

Fernald (8) includes var. incisum Gray, a variety bearing leaves sharply and coarsely toothed at the base, from Southeast Virginia. The toothed margins are variable at best and this variety seems based on arbitary decisions and following Clewell and Wooten (27) it is not recognized in the Virginia flora.

Massey (14) reports this species from Pulaski and Accomack Counties though the specimens have

not been personally examined.

2. Ageratina altissima (L.) King & Robinson. White Snakeroot.

Perennial herbs to 10 (-11.5) dm tall; stems glabrous to short-villous, simple or branched from the upper nodes; leaves thin and submembranous, ovate to less commonly deltoid, 6-15 (-16) cm long, 4.5-11 (-12.6) cm wide, base rounded to truncate, apex at times noticeably acuminate, margins crenate to serrate, bearing from 11–23 (average of 18) teeth per margin, borne on petioles 2–7 (-7.2) cm long; corymbs dense, convex, heads 11-22 flowered; involucres cylindric when young, becoming widespread in fruit, 3.5-6.5 (-7.0) mm long, corollas white, (2.20-) 3-4 (-4.5) mm long, achenes (1.5-) 2-2.25 mm long, pappus 2-3 (-3.5) mm long. 2n = 34 (12, 27).

Key to varieties:

Leaves 6-11 (-16) cm long, 4.5-7.5 cm wide borne on petioles 2-4.5 (-7) cm long; involucres 3.5-5.5 mm long; widespread over Virginia.....2a. var. altissima. Leaves 10-18 cm long, 7.5-12.6 cm wide, borne on petioles 4-7.2 cm long; involucres (5.0–) 5.5–7.0 mm long; mountains......

2a. Ageratina altissima (L.) King & Robinson var.

altissima.

Eupatorium rugosum Houtt.

Eupatorium urticaefolium Reichard

Eupatorium urticaefolium Reichard var. villicaule Fern. Type: Bedford County. Curtis s.n. (GH). Eupatorium rugosum Houtt. var. chlorolepis Fern. Type: Surry County. Fernald and Long 14034 (GH).

See characters listed in the key immediately above. Abundant over the state with a possible exception in the extreme outer Coastal Plain (Fig. 5) on wooded slopes and river banks, in damp woods and boggy areas, on roadsides, less commonly in drier habitats; it is at times associated with shale. Massey (14) includes the counties of Henrico, Scott and Tazewell in the distribution though these specimens have not been seen personally. The total range extends from Gaspe and Nova Scotia south to Michigan, Wisconsin and Minnesota and to northwestern Florida (27). In Virginia, this species is in flower and fruit from (late July-) August to mid-October. Fruits were dispersed on Fernald and Long 14031 (NY) collected on October 13.

Variety villicaule Fernald includes those specimens with loosely villous stems and petioles (8). Morphologically, this character is not distinct. However, Allard (28) reports forma villicaule is only found at lower levels of the Massanutten Mountains in rich woodlands while A. altissima (Eupatorium rugosum) may occur anywhere. These forma (varieties) may be distinctive ecologically but this aspect needs study.

Variety chlorolepis Fernald, based upon a specimen with "corrugated phyllaries" (8), is not morphologically distinct and thus not included here.

An apparent rarity in which the leaves are in whorls of three is seen on Uttal 7708c (VPI) from

Bland County.

Ageratina altissima contains tremetol and glycosides which can be poisonous to cattle, sheep and man. A disease, "Milk Sickness," can result in man by drinking raw milk from cows which have eaten White Snakeroot. Milk sickness symptoms include weakness, nausea, vomiting, prostration and at times, death (29, 30).

2b. Ageratina altissima (L.) King & Robinson var. roanensis (Small) Clewell and Wooten.

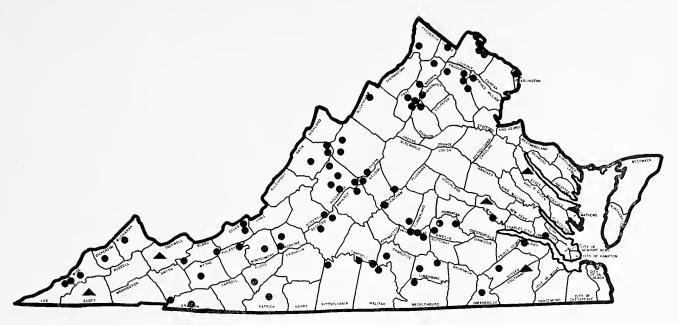


Fig. 5—Distribution of Ageratina altissima var. altissima in Virginia. Closed dots indicate exact locations; triangles indicate a collection from that county but without specific location data.

Eupatorium roanensis Small

Eupatorium rugosum var. roanense (Small) Fernald

Distinguished by the large leaves and the longer involucial phyllaries as noted in the key above.

Relatively common on mountain slopes from Page County in the north to Washington County in the south (Fig. 6) (see also ref. 27) in rich woods, a distribution similar to *Liatris turgida* and *L. scariosa* (1) and which follows closely the limits of the Oak-Chestnut forest region (31). Open circles on Fig. 6

represent specimens mapped by Clewell and Wooten (27); the symbol in Craig County represents the collection cited by Massey (14). The range of this variety continues south to northern Georgia and westward to eastern Kentucky and Tennessee (27). It is in flower and fruit from August through September in Virginia.

This variety intergrades with var. *altissima* but is readily distinguished by the longer phyllaries which become conspicuously twisted in the dried material.

Intergrades between A. aromatica and A. altissima

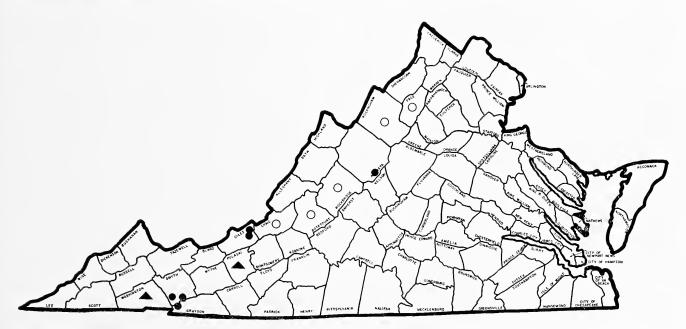


Fig. 6—Distribution of Ageratina altissima var. roanensis in Virginia. Closed dots indicate exact locations; open circles indicate specimens cited in literature though all specimens have not been seen personally. Triangles indicate a collection from that county but without specific location data.

are reported from Craig, Nansemond, Patrick, Rockingham, Southampton, Washington and Westmoreland Counties and cities of Hampton and Virginia Beach and the suggestion of hybridization is made (27). I have seen specimens (Ahles and Clark 60098, Patrick Co., UNC; Allard 1091, Fauquier Co., VPI) annotated by the above authors (27) as "Eupatorium aromaticum L. towards E. rugosum." Data from morphological measurements of these plants are not indicative of hybridization as the "intergrade" fits well within the variation of A. aromatica. See Table I.

3. Conoclinium DC.

Pubescent herbs from perennial roots and rhizomes. Leaves cauline, opposite, petioled, ovate to subcordate, crenate. Heads campanulate, in corymbose clusters, (40–) 50–70 flowered. Involucral bracts narrow, acute. Corolla tubular, glandular, bluish to bluish-violet. Receptacle conical, glabrous. Achenes prismatic, sparsely glandular. Pappus of scabrous setae.

Conoclinium, a genus of three species native to

TABLE I

A comparison of A. aromatica, A. altissima
and the proposed intergrade

A. aromatica	"intergrade"	A. altissima
3.5–8.0 cm	5.5–6.8 cm	6-11 '-16) cm
(1.6-) 2-4 (-4.5) cm	3-3.7 cm	4.5–7.5 cm
0.3-1.5 (-2.0) cm	1.1-2.1 cm	2-4.5 (-7) cm
3.75-4.5 mm	3–3.5 mm	(2.2–) 3–4 (–4.5) mm
	3.5–8.0 cm (1.6–) 2–4 (–4.5) cm 0.3–1.5 (–2.0) cm	3.5–8.0 cm 5.5–6.8 cm (1.6–) 2–4 3–3.7 cm (-4.5) cm 0.3–1.5 (-2.0) cm 1.1–2.1 cm

the southeastern United States, southwestern United States and Mexico (5) has been submerged in Eupatorium s.l. by most students of the Eupatorieae. However, Small (32) recognized the genus as distinet from Eupatorium based upon the presence of extremely narrow involucral bracts and a conical receptaele. Grant (12) later reported a different karyotype for E. coelestinum when compared with other Eupatorium species in that the chromosomes of the former are extremely small (1-2 μ in length). King and Robinson (5) report papillose inner and outer surfaces of the corolla, and the presence of glands on the corolla. The combination of these characters (extremely narrow phyllaries, conical receptacle, very small chromosomes and papillose, glandular corallas) is not present in Eupatorium and thus the genus Conoclinium is again recognized as separate and a part of the Virginia flora.

Conoclinium is represented in Virginia by the

following single species.

1. Conoclinium coelestinum (L.) DC. Mistflower, Blue Boneset, "Ageratum."

Eupatorium coelestinum L.

Stems sparingly branched, 4–7 dm tall; leaves (2.5-) 3–8.5 cm long, (1.6-) 3–5 cm wide, borne on petioles to 3 cm long; heads numerous, in corymbose clusters; involucral bracts 3–4 mm long, 0.25-0.5 mm wide, subimbricate, subequal; corollas bluish to violet, ca. 3 mm long, the style exerted about 3 mm; achenes 1.3-1.5 mm long; pappus 2.5-3 mm long. n=10 (12).

Conoclinium coelestinum is common in marshes, moist roadside ditches, meadows, swales, bordering ereeks and other similar moist habitats generally throughout the Coastal Plain, becoming less common in the Piedmont and the Mountains. (Fig. 7). This distribution is similar to that of *Liartis graminifolia*



Fig. 7—Distribution of *Conoclinium coelestinum* in Virginia. Closed dots indicate exact locations; triangles indicate a collection from that county but without specific location data.

var. typica (1). Mistflower is reported to be common in the Williamsburg area (33) and reported as undocumented from the Shenandoah National Park (34). This paper, however, documents the records from that Park. The species range extends from New Jersey, Pennsylvania, Ohio and Indiana on the north to Florida and inland to Missouri and Kansas (8, 9). It is in flower and fruit from (late July-) mid-August through mid-October.

An apparent rare white flowered form, forma *alba* Alex. (35) is reported from West Virginia (25) but is unknown from Virginia, though *Barrans 498* (UNC) from James City County shows very pale blue corollas which may approach forma *alba*.

Conoclinium is readily recognized by the coneshaped receptacle bearing lovely blue to violet flowers subtended by very narrow involucral bracts. It is known as an attractive cultivar and may escape from the garden.

4. Fleischmannia Schultz-Bip.

Perennials with ascending solid stems. Lcaves opposite. Receptacle flat. Flowers pink, borne in loosely branched corymbs. Involucral bracts ca. 30, narrow, in 2–3 subequal series. Achenes prismatic. Carpopodium distinct. Pappus of 5–40 slender and sometimes fragile setae.

Fleischmannia has been recharacterized by King and Robinson (3) and is treated as a natural entity based upon analysis of microscopic features of ex-

ternal floral morphology.

The genus, consisting of 53 species native to the New World (3) is represented in our flora by the following single species.

1. Fleischmannia incarnata (Walter) King & Robinson. Pink Thoroughwort.

Eupatorium incarnatum Walter

Perennial herbs ca. 10.5 dm tall; leaves opposite, deltoid, 5–8.8 cm long, 4–6.6 cm wide, margin crenate, apex acuminate, base truncate, the two lateral veins parallel to the midrib and appearing triplinerved, borne on petioles (2.0-) 4–5.5 cm long; the longest involucral bracts linear, subequal, 5–5.25 mm long, ca. 0.75 mm wide, 2-ribbed, acute, glabrous, subtended by much shorter, pubescent bracts; corollas pink or lilac; pappus white, the individual setae thin and somewhat flexuous in dry material. 2n = 20 (12).

This southern species associated with rich woods and wooded swamps extending from Mexico and along the Gulf Coast north to southern West Virginia, Ohio, Indiana, Illinois and Missouri (8), has been collected four times in Virginia: Bedford Co.: pine woods, Sept. 12 (in flower) Hening s.n. (VMI); Princess Anne County: waste places, Munden, September 3, (in bud and flower), McKenzie 1773 (GH, NY); Surry County: calcareous woods W of Claremont, August 28 (in bud), Fernald and Long 12856 (NY, US, VPI, GH); West of Claremont, Oct. 10 (fruit) Fernald and Long 14023 (GH). It may be expected from south-central Virginia as Radford, et al. (7) report this species from Warren County, N. C.

Fleischmannia incarnata most closely resembles Conoclinium coelestinum from which it is distinguished by the flat receptacle bearing pink corollas.

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Daunomycin—Induced Cytological Alterations in Root Meristems of Vicia faba

Abstract—The effect of daunomycin (DM) on structural changes in Vicia faba chromosomes was investigated and compared with some of the reported effects in mammalian cells. The frequencies of various types of aberrations were very low and exchanges were the least observed structural changes. Distribution of chromatid and isochromatid breaks did not suggest specificity in terms of point of breaks either among chromosome groups or within a chromosome. The occurrence of aberrant mitosis is suggested to result from DM-induced changes in the chemical cytogenetic programming of portions of genomes, which regulate the functional mechanism of the spindle system.

Daunomycin (DM) is a chromoglycoside with an anthracycline type ring system as a chromophore. It has been used since 1963 as an antibiotic against childhood leukemia and solid tumors (1), Reported findings indicate that the drug forms complexes with DNA and inhibits both cellular RNA and DNA synthesis (2). It is further suggested that the inhibition of nucleic acid synthesis by DM is due to the binding of the drug between adjacent base pairs in the helical DNA (3, 4). Consistent with this view are the observations that DM causes inhibition of DNA-dependent RNA polymerase (2), a decrease in the viscosity of DNA (5), a decrease in the sedimentation coefficient of DNA (5) stabilization of DNA to heat denaturation (6), stiffening and/or elongation of DNA molecule (7), and causes changes in the optical density of DNA (7).

The cytotoxicity, cytostaticity and mutagenicity of DM has been investigated by many workers (1, 8–13). The findings of Di Marco *et al.* (8) indicate that the antibiotic exerts a marked inhibitory effect on mitotic activity. Vig *et al.* (10) reported its chromosome-breaking action on cultured human leukocytes, Ostertag and Kersten (9) showed that DM caused no chromosome aberrations in HeLa cells, and Bempong (11–13) reported on the cytogenetic and cytological effect of DM in *Vicia faba*.

Since most of the available reports on the cytoxicity and mutagenicity of DM have been limited to mammalian cells, this fourth paper in a series of studies describes the effects of the antibiotic on 1) chromosomal rearrangement, 2) distributions of aberrations among chromosomes and within a chromosome, 3) mitotic activity and 4) chromosome behavior, in *Vicia faba*.

Materials and Methods

Two cm long roots of *Vicia faba* were used in the study. The secdlings were germinated in the greenhouse at 20°C. Following the emergence of the primary roots, the seedlings were transferred to Coplin jars, where they were grown in well aerated tap water at 20C in the dark. The various concentrations of DM used were prepared with distilled water. During the treatments, air was bubbled through the solution surrounding the roots. After treatment, the seedlings were thoroughly washed in running water and then put back in tap water through which air was bubbled, and allowed varying durations for recovery. The concentrations of DM used and the recovery periods allowed for each treatment are presented in Table I. All the lateral roots received the same duration of treatment (1 hour exposure to the chemical); the only variables were the concentration of the chemical and duration of the recovery period. Three hours prior to fixation some of the roots were treated in colchicine solution (0.025%) to enhance wellspread metaphases. Roots were fixed in alcoholacetic acid (3:1) overnight and slides were prepared as Feulgen squashes.

Results

Types of chromosome aberration: Structural changes in chromosomes scored were chromatid breaks (B'), isochromatid breaks (B"), chromatid exchanges (C'-C'), isochromatid exchanges (C"-C"), chromatid breaks in the secondary constriction (S-C/B"), chromatid gaps (G'), and isochromatid gaps (G"), (see Fig. la-h). The other noticcable chromosomal or nuclear changes were proximal and distal sister chromatid unions, (Fig. 1b & e) micronuclei, elongation and spiralization of chromosomes (Fig. 2) anaphase and nuclear bridges (Fig. 3-4). In some of the preparations chromosomal erosion and very extensive pulverization of the entire somatic complement were observed (Fig. 5).

It is evident from Table I that the spectrum of aberrations induced by DM in *Vicia faba* is not as extensive and drastic as those reported for human leukocytes (10) or the chromosome breaking action

of other mutagens in Vicia faba (14, 15).

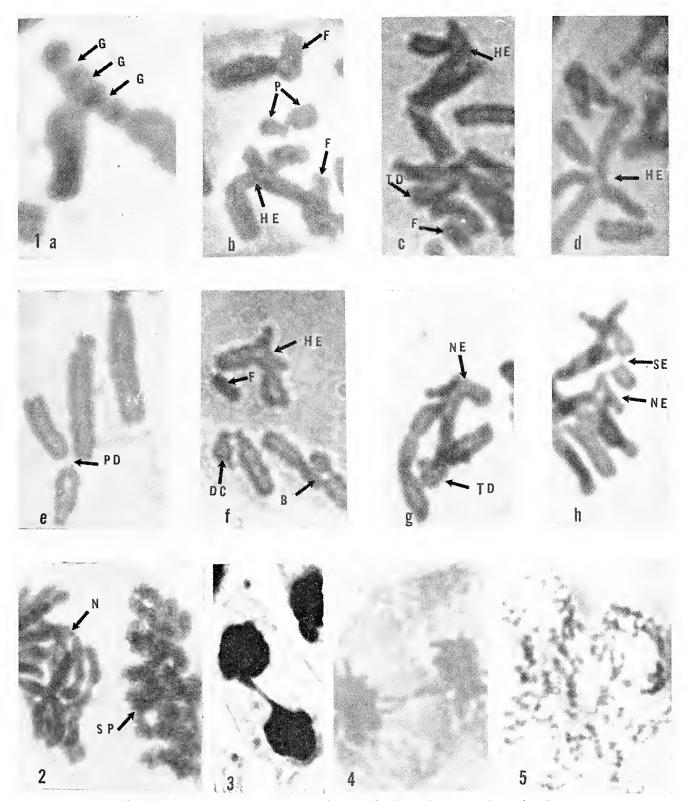


Fig. 1a-5—Chromatid and isochromatid aberrations produced by DM in Vicia faba root meristematic cells.

1a—Isochromatid gaps in a long chromosome (G).

- b-Multiple aberrations: homologous exchanges (HE), proximal sister unions (P), and acentric fragments (F).
- c-Homologous exchanges between two short chromosomes (HE), terminal deletion (TD), and an acentric fragment (F).
- d—Homologous exchanges between two long chromosomes (HE).
- e—Proximal and distal sister unions (PD).

 f—Multiple aberrations—Homologous exchanges (HE), acentric fragment (F), a short dicentric chromosome (DC), and chromatid break (B).
- -Nonhomologous exchanges (NE) and terminal deletions (D).
- h-Nonhomologous exchanges (NE) and apparent subchromatid exchanges (SE).
- 2—Spiralized chromosomes (SP). The coils are clearly visible.
- 3-Nuclear or chromatin bridge.
- 4—Interlocked anaphase bridges.
- 5—Eroded or pulverized chromosomes.

Types and frequency of chromosomal aberrations induced by daunomycin. One hundred cells were scored for each treatment and control.

DM Concentration (µg/ml)	Period of Recovery (hr)	Abnormal cells (%)	Aberrations per 100 cells						Aberration per	Break events		
			B'	B''	C'-C'	C''-C''	S-C/B'	S-C/B"	G′	G"	analyzed metaphase	per analyzed cell
Control		0	0	0	0	0	0	0	0	0	0	0
5.0	24	2	-	1	_		_	1	_	_	0.02	0.02
5.0	48	8	1	3	-	_	0	3	_	4	0.11	0.07
6.0	24	6	3	1	_	_	0	2		_	0.06	0.05
6.0	48	9	5	11	_	-	9	5	3	7	0.40	0.30
12.0	24	8	5	4	1	-	1	3	1	4	0.19	0.13
12.0	48	17	7	9	2	1	2	7	5	8	0.41	0.25
25.0	24	13	1	2	2	-	4	5	1	7	0.22	0.12
25.0	48	22	13	10	6	1	5	7	4	12	0.58	0.35

The frequencies of the various types of aberrations scored were very low and exchanges were the least observed structural abnormalities. There was a trend toward a high percentage of aberration yield with an increase in DM concentration, however, the trend did not hold in all cases. Chromatid and isochromatid exchanges and to some extent, isochromatid breaks at the secondary constriction, were the only cytological abnormalities that showed a correlation between concentration of DM and percent abcrration. Chromatid and isochromatid gaps scored after 48 hours of treatment indicated an apparent increase with an increase in DM concentration. The other structural changes revealed unaccountable fluctuations in their aberration frequencies in relation to the concentration of DM.

Table I further demonstrates that in *Vicia faba* higher concentrations of DM are required to induce chromosomal aberrations. This finding is at variance with that of Vig *et al.* (10), which suggests that DM requires a narrow dose to induce chromosomal aberrations. Their data showed that $0.015 \ \mu g/ml$ of DM produced 97 exchanges and 194 breaks of various types in about 800 cells scored in human leukocytes. Our study, as revealed by the data in Table I, shows that a concentration as high as $5.0 \ \mu g/ml$ of DM produced only a total of 9 breaks and no exchanges in 400 cells scored. Twenty-five $\mu g/ml$, about 1,666.6-fold increase of the concentration used by Vig *et al.* (10), produced 0.26 breakage-exchange per analyzed cell (the figure excludes breaks at the secondary constriction).

Distribution of aberrations: Fig. 6 shows the distribution of chromatid and isochromatid breaks among the 6 pairs of chromosomes. The two long, metacentric chromosomes were grouped in class 1, 4 pairs of the submetacentric chromosomes in class 2 and in class 3, the 2 shortest of the submetacentric chromosomes. The 78 chromatid and isochromatid breaks analyzed seemed to suggest no specificity in terms of point of break either among chromosome groups or within a chromosome. According to Fig. 6 the six pairs of chromosomes neither show a differential susceptibility to the drug nor are the points of break limited to certain heterochromatic regions as observed for mitomycin C effect in *Vicia faba* (14). It must be mentioned, however, that while all the

chromosomes showed randomly distributed regional susceptibility to aberration, breaks at secondary constrictions and centromeres were more frequent in all the chromosomes.

Aberrant mitosis: Roots treated with DM and fixed immediately or 12 hours after treatment showed no aberrations. In fact the mitotic index was so low during this period that we could hardly find well-spread metaphases. In roots allowed 24 hours of recovery, only a few aberrant chromosomes were observed, thus characterizing DM as producing a delayed type of effect in Vicia faba. The mitotic inhibition observed during the first 12 hours of treatment was reduced with an increase in the recovery period. The peak of chromosomal aberration appeared at 48 hours.

Since some of our colchicine-treated preparations showed an unexpectedly high incidence of mitotic irregularities, particularly when $25 \mu g/ml$ of DM was used, some of the lateral roots exposed to the same concentration of DM were not treated with colchicine prior to alcohol-acetic acid fixation. The incidence of different types of anomalous mitosis observed in the treated material was as follows: apparent tripolar and tetrapolar anaphases (Fig. 7, 8), C-anaphases, characterized by abnormal orientation of chromatids (Fig. 9), and endoreduplicated cells (Fig. 10). In some of the cells chromosomal movement and distribution appeared to indicate somatic reduction (Fig. 11).

In Table II, the frequency of the various types of aberrant mitotic cells is presented. The data seem to suggest an increase in cytological anomaly as the concentration of DM was increased. A detailed analysis of the effect of 25 μ g/ml of DM on mitotic activity after 24 and 48 hours of treatment is shown in Table III. The data indicate that at this concentration, mitosis was arrested at metaphase during the second cell cycle; however, a significantly reduced number of anaphases was observed.

Chromosome behavior: Irregular distribution of chromosomes, presumably arising from a disrupted spindle mechanism, was observed in most of the non-colchicine-treated preparations. The incidence of this aberrancy increased as the concentration of the anti-biotic was increased. As shown in the histogram (Fig. 12), the number of chromosomes per cell

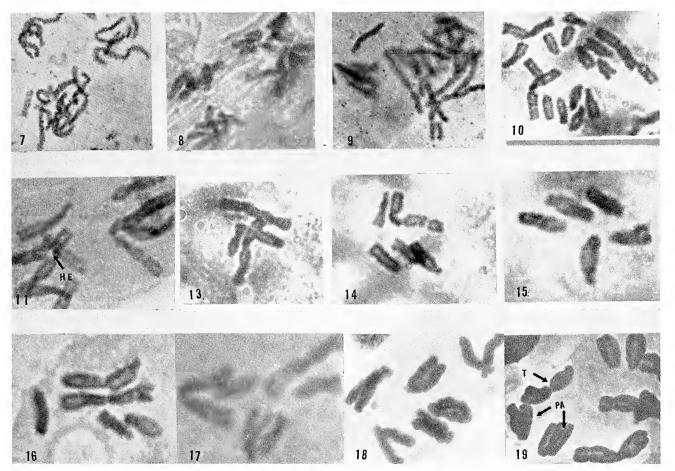


Fig. 7–19—Abnormal mitotic chromosome movement and distribution.

- 7—A tripolar anaphase.
- 8—Precocious anaphase. The tetrapolar orientation and distribution of the chromosomes are suggestive of anaphase 11. Note that the chromosomes have not split into chromatids.
- 9—C-Anaphase cell. Observe the lack of definite orientation of the chromatids.
- 10—C-metaphase configuration of an endoreduplicated cell.
- 11—An apparent somatic reduction division. Each group contains six chromosomes. Note the homologous exchanges in one of the groups (HE).
- 13—A cell containing four (2 long and 2 short) chromosomes.
- 14—A cell containing five (one long and 4 short) chromosomes.
- 15—There are five short chromosomes in the cell.
- 16—A true haploid cell—one long and five short chromosomes.
- 17—"Pseudo-haploid" cell—two long and four short chromosomes. 18—"Pseudo-haploid" cell—contains six short chromosomes.
- 19—Somatic chromosome associations. All the associations are of homologous types and are either parasynapsis (PA) or telosynapsis (T).

TABLE II Per cent aberrant initotic cells induced by dannomycin

DM Concentra- tion (µg/ml)	Endore- duplication	Multi- polar anaphases	Chromatin bridges	Anaphase bridges
5	0.72	0.31	3.43	2.84
6	0.76	0.29	3.65	4.17
12	6.81	4.62	8.32	4.78
25	10.42	7.36	13.54	5.51

TABLE III

Effect of 25 μ g/ml of DM on mitotic index and frequency of the different mitotic stages after treatment of Vicia faba lateral roots

Period of recovery (hr)	Mitotic index (% per 100 cells)	Frequency of prometaphase per 100 meta- phases	Frequency of anaphase per 100 metaphases
24			
Control	49.3	12	5
Treated	10.8	249	42
48			
Control	51.2	10	7
Treated	27.9	397	2

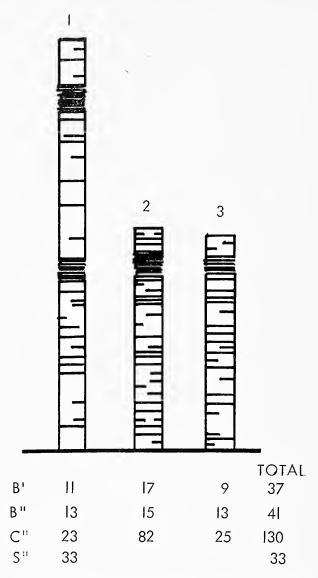
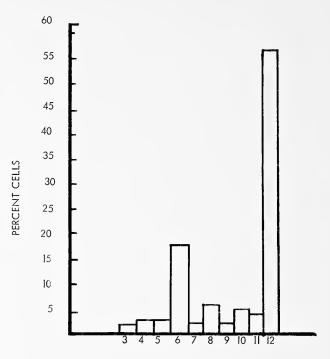


FIG. 6—Distribution of points of chromatid and isochromatid breaks in DM-treated *Vicia faba* root meristematic cells. Short lines represent B' and long lines B". C" and S" denote isochromatid breaks in the centromere and secondary constrictions respectively. (The figures, 1, 2, and 3, represent the classes of chromosomes as described in the text.)

ranged from three to twelve (Fig. 13–18). Eighteen per cent and 57 per cent of the cells scored had six and twelve chromosomes respectively. On the basis of their karyotypes three types of haploid cells were observed. These were: 1) cells with one half the total complement, i.e. one metacentric and five submetacentrics (Fig. 16), 2) cells with two metacentrics and four submetacentrics (Fig. 17), and 3) cells containing six submetacentric chromosomes (Fig. 18). The last two groups of "pseudo-haploids" were more prevalent than the "true-haploids". Most of the cells with less than six chromosomes appeared distorted and small. Another interesting observation was what appeared to be somatic associations in some of the metaphases (Fig. 19). These associa-



NUMBER OF CHROMOSOMES PER CELL

Fig. 12— Frequency of distribution of number of chromosomes per cell in *Vicia faba* root meristematic cells treated with 12 and 25 μ g/ml of DM. (Fifty cells were counted in each treatment and pooled.)

tions were of two types: end-to-end (telosynapsis) or side-by-side (parasynapsis).

Discussion

The data presented reveal that DM induced structural changes in the chromosomes of Vicia faba, however, the frequency of aberrations was very low. The chromatid and isochromatid exchanges commonly found in DM-treated human leukocytes (10) were very few even at higher concentrations of the antibiotic. Furthermore, translocations and dicentrics were rarely observed in our preparations. The differential effect of DM on different cells as reported by Ostertag and Kersten (9), Vig et al. (16) and Bempong (11, 12), suggests that the quality and extent of damage caused by the drug was dependent upon the nature and source of the experimental materials and the susceptibility of the chromosomes or parts of the chromosomes to the breaking action of the chemical. If this assumption is valid, then it is not unusual that a drug which is capable of 1) inhibiting cellular DNA and RNA synthesis, 2) causing cross-linking of DNA, and 3) complexing with DNA in vitro as well as in vivo, fails to induce chromosomal aberrations in HeLa cells or causes few aberrations in Vicia faba root meristematic cells. However, in human leukocytes, severe chromosomal structural changes are observed in the presence of DM.

The spectrum of chromosomal aberrations as presented in Table I and summarized in Fig. 6 does not indicate specificity of DM in its chromosome-breaking action in *Viciā faba*. This observation is at vari-

ance with the findings of Vig et al. (16), who reported specificity of DM in causing chromosomal rearrangements in human leukocytes. The few chromatids and isoehromatid exchanges scored did not indicate preferential exhanges between certain chromosomes, and the origin of breaks was not limited to specific regions on the chromosome length or specific points among chromosome groups.

Association of homologous chromosomes during mitosis has been reported in some plant and animal species (17–19). A spatial proximity hypothesis has been proposed (10). This hypothesis considers somatic association as a primary role of the centromere. Telomeric initiation of pairing is also believed to trigger somatic associations (18, 20). The occurrence of parasynapsis, which suggests centromeric initiation of pairing and telosynapsis, which may imply telomeric initiation of association, may lead one to infer that the general phenomenon of somatic association is a gene-controlled event.

The recent findings of Avivi et al. (21) eloquently demonstrated that in the somatic cells of common wheat, association of homologous chromosomes is regulated by somatic-association genes. Implicit in the report was the supposition that the genes achieved their regulatory effect by controlling the functional characteristics of the spindle system. They pointed out that the degree of effective suppression or enhancement of somatic association was dependent on the doses of the somatic association

The evidence of irregular chromosome separation, C metaphases and anaphases, precocious anaphases, somatic reduction and association, are suggestive of disrupted spindle mechanism. It might be plausible to infer that DM affected a complex of synthetic reactions related to spindle fiber formation and function. The literature shows that microtubules of the spindle fibers exist in a dynamic equilibrium with their subunits (22, 23). In the presence of drugs that are capable of causing mitotic poisoning, this equilibrium can be disturbed and shifted towards dissociation. Since microtubular proteins consist of the fibrous component of the spindle system, which is responsible for chromosomal movement and distribution, physical or chemical changes in the spindle microtubules will culminate in mitotic aberration.

The ability of DM to induce chromosomal structural changes (2, 3, 9, 20), to form complexes with nucleic acids, to inhibit synthesis of DNA-dependent RNA polymerase (8, 17, 22), and to alter the physiochemical properties of DNA (11, 12), confer upon the drug a potential for modifying or completely changing the chemical cytogenetic programming of certain portions of the genome. The sug-

gestive implication of the regulatory action of DM may include the control of portions of genome which dictate essential mitotic events such as the functional characteristics of the spindle system and the associated chromosomal distribution.

Acknowledgments

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Multiple Discriminant Analysis: A Repeated Measures Design*

Abstract—Conventional multiple discriminant analysis requires that the various treatment groups be independent of one another, i.e., the same subjects cannot be measured under each treatment condition. The present paper describes a simple technique which permits multiple discriminant analysis to be employed even though the same subjects are measured on multiple variables under each experimental condition.

Introduction

Multivariate analysis of variance has been of real value to investigators interested in problems that cannot be described adequately in terms of single variables. This analysis tests for treatment effects in terms of multiple dependent variables considered simultaneously—while taking into consideration the interrelationships among variables.

Conventional multivariate analysis of variance requires that the various treatment groups be independent of one another (1, 2). This is unfortunate since there are many research applications in which it would be desirable to measure each subject on multiple variables under each experimental treatment condition. For instance, in an investigation into the effects on driving performance of various dosages of alcohol, it might be desirable to test each individual at each dosage. This paper describes a repeated-measures multiple discriminant analysis (one-way multivariate analysis of variance) technique which is appropriate for such situations.

Method

In the usual multiple discriminant analysis there are K groups of items with N_k items in the kth group and observations of M variables for each item in each group. It is assumed that the observations on items in group k (k = 1, 2, \cdots , K) come from an M-variate normal distribution with mean vector μ_k and variance-covariance matrix V. That is, it is assumed that the mean vector is characteristic of a

particular group of items but that the variance-covariance matrix is common to all groups.

The degree to which it is possible to discriminate between groups depends, in part, on the size of the elements of V.

A comprehensive model of variable m for item i in group k is

$$X_{\min k} = \mu_{\min k} + \alpha_{\min k} + \epsilon_{\min k}.$$

where $\alpha_{\rm mik}$ is a random error associated with differences between items and is distributed normally with mean 0 and variance σ_{α}^2 , and where $\epsilon_{\rm mik}$ is a random error associated with differences within items and is distributed normally with mean 0 and variance σ_{ϵ}^2 .

In the usual multiple discriminant analysis no distinction is made between items (since there are different items in each group and they must be considered a source of variation). Equation 1 can be written

$$X_{\text{mik}} = \mu_{\text{mk}} + \epsilon'_{\text{mik}}$$

$$\epsilon'_{\text{mik}} = \alpha_{\text{mik}} + \epsilon_{\text{mik}}$$
2

where

 ϵ'_{mik} is distributed normally with mean 0 and variance σ^2 , and

$$\sigma^2 = \sigma_{\alpha}^2 + \sigma_{\epsilon}^2.$$

That is, in the model for a single variable in the usual multiple discriminant analysis, the error is not considered to consist of two components, and no advantages would result from considering two components.

It would be possible to perform a multiple discriminant analysis in which observations of M variables were made on each of N items under K different treatments instead of in K different groups. In such an analysis, variation due to items could presumably be removed thus increasing the chance of discrimination between treatments.

The appropriate model of variable m for item i under treatment k would be

$$X_{\text{mik}} = \mu_{\text{mk}} + \alpha_{\text{mik}} + \epsilon_{\text{mik}}$$
 3

^{*} Those wishing to obtain a Fortran IV multiple discriminant analysis program (with repeated measures option) should request one from the senior author; example problems will also be provided. This program is a modification of one reported by Veldman (3). In its present form it operates on a Xerox Data Systems (XDS) Sigma 5—a 32K machine. It may require minor modifications to run on other machines.

In this instance, because each item appears under each treatment (in each group, so to speak) α_{mik} can be considered to be a constant associated with item i and variable m rather than a random error. All treatment differences can be absorbed by μ_{mk} just as they would be in the regular analysis and equation 3 can be written

$$X_{\min k} = \mu_{\min} + \alpha_{\min} + \epsilon_{\min k}$$

Without loss of generality it can be assumed that

$$\sum_{i=1}^{N} \alpha_{mi} = 0.$$

With equation 4 and its underlying assumptions, one can remove differences between items, and, consequently, variation due to differences between items, by adjusting observations before the multiple discriminant analysis. This adjustment can be made by subtracting the appropriate value of $\alpha_{\rm mi}$ from each observation before the analysis.

Estimates of α_{mi} can be made using X_{mik} from equation 4 as follows:

$$\hat{\alpha}_{mi} = \frac{1}{K} \sum_{k=1}^{K} X_{mik} - \frac{1}{NK} \sum_{i=1}^{N} \sum_{k=1}^{K} X_{mik}$$

With these adjustments the model of variable m for item i under treatment k (equation 4) becomes

$$X_{mik} = \mu_{mk} + \epsilon^{\prime\prime}_{mik}$$

the same as equation 2, the model for the usual multiple discriminant analysis.

The adjustment process makes ϵ''_{mik} a combination of within-item errors rather than a single random error as it was in equation 2. However, ϵ''_{mik} should be on the order of 1+1/NK+1/k times as large as ϵ_{mik} in equation 1 and presumably much smaller than ϵ'_{mik} in equation 2.

Thus, with the adjustment in observations, a multiple discriminant analysis can be performed for this situation (K treatments instead of K groups) exactly as in the usual multiple discriminant situation. There will be three main differences in the analyses and results:

- 1. The elements of the variance-covariance matrix will be smaller and discrimination between treatments should be much better than if the analyses had been performed with no adjustment.
- Wherever the values N_k appear in the usual multiple discriminant analysis they should be replaced by N.
- 3. If there are auxiliary univariate analyses of variance based on the adjusted observations, degrees of freedom in some of these analyses may have to be adjusted.

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Nutrient Factors Limiting Primary Productivity in Simulated and Field Antarctic Microecosystems

Abstract—We compared, both in laboratory microecosystems and under natural field conditions, the effects of selected nutrient enrichments on the algal communities of two closely associated Antarctic lakes for the purpose of discovering which inorganic nutrients might most likely be responsible for the observed "trophic" differences between them. Laboratory aquatic microecosystems simulating both lakes were established in several types of containers with living microbial communities from both lakes. Effects of enrichments with ammonia, phosphate, nitrate, silicate, iron, and chloride singly and in combinations were examined periodically for 30-40 days, by evaluating photosynthetic ¹⁴C uptake rates by phytoplankton. Ammonia was the principal nutrient causing the differences in primary productivity between the two lake microecosystems. Phosphate also induced a small but significant stimulation of primary productivity, especially in combination with ammonia. Other enrichments were ineffective. These comparative laboratory microecosystem studies revealed that ammonium ion concentration is a major factor causing productivity differences observed earlier in the field. Subsequent field enrichment studies, although conducted during a second season, essentially confirm these laboratory results.

Introduction

During the Antarctic summer of 1969–70 we studied two small lakes which had strikingly different phytoplankton productivity levels yet were located only 500 m apart and three km from the U.S. Palmer Station, on Anvers Island, Antarctica (64°46′S, 60°05′W). Field comparisons of these two lakes disclosed relatively few parameters (geologic, morphometric, physical, chemical) which offered promise of explaining their *in situ* biological differences (primary productivity, algal biomass, extractable chlorophylls, species diversity) (1–4). These parameters were the concentrations of phosphate (0.03 and 1.7 mg/l, as total P), ammonium (0.10 and 2.5 mg/l, as N), chloride (7.5 and 35.0 mg/l, as HC1) and nitrate (1.0 and 1.75 mg/l, as N) re-

spectively for oligotrophic Lake no. 1^1 and eutrophic Lake no. 2^1 . Levels of iron, silicate, and carbon (as CO_2 and HCO_3^-), as well as other chemicals analyzed, differed relatively little between the two lakes (2). However, the low values for iron, (≤ 0.02 mg Fe⁺⁺/1), and the combined scarcity of diatoms with low dissolved silica (≤ 0.76 mg SiO₂/1) in most of the freshwater habitats visited near the U.S. Palmer Station suggested these nutrients might also limit algal production in these Antarctic ecosystems.

Following this Antarctic summer study, we returned to V.P.I. & S.U. with microbial communities from both lakes and established microecosystems in our laboratory which resembled both lakes sufficiently to perpetuate the algal communities and enable our testing of nutrients influencing the observed trophic differences in Antarctic waters during austral summer conditions. A second visit to the lakes was made during the 1970–71 field session. This revisit enabled field enrichment studies to test the validity of data obtained from the more artificial laboratory microecosystems.

Biological research in Antarctica is usually restricted to a very short period for making field observations. Furthermore, adverse weather conditions, the lack of several items of equipment plus limited scientific logistic support facilities at Palmer Station, made it impossible to conduct all this research in the field. Finally no limnological studies have been reported previously from the western portion of the Antarctic Peninsula, nor have studies of the cause of eutrophication been made anywhere in Antarctica.

¹ Lake no. 1, unofficially called "Skua Lake," is located behind the abandoned United Kingdom base at Norsel Point, Anvers Island; lake no. 2, unofficially called "Humble Lake," occurs on Humble Island in Arthur Harbour, 500m from lake no. 1.

Materials and Methods

A Wisconsin plankton net, 76 μ pore diameter, was employed in the field for collection of the larger phytoplankton. Foerst centrifuge-concentration of seston collected with a Kemmerer bottle as well as filtration-concentration through 0.8 μ Millipore membranes were employed for detection of nanno- and ultra-plankton, including delicate flagellates (5). Phytoplankton were identified to genus with a binocular phase microscope, and to insure detection of nanno-plankton and delicate flagellates, field examinations with a Nikon field microscope were made routinely.

Living microbial communities, including algae, bacteria, yeasts, and protozoa from plankton tows, water bottle collections, Foerst centrifuged samples, and sediment samples, from both lakes were transported aseptically and under refrigeration to our laboratory in enrichment media. These media were specifically designed not to exceed any inorganic nutrient concentrations determined for these two lakes by more than 50%. Cultures were maintained in our laboratory in growth chambers at 5 C and 5000 lux of continuous fluorescent illumination. The algae in our microbial communities consisted only of genera which had dominated in numbers and biomass during our field studies. A number of the subdominant and rare algal species, which have been cited by Parker, Samsel, and Prescott (3), did not survive in our enrichment cultures.

Aquatic microecosystems representing Antarctic lakes 1 and 2 were simulated with 600 ml Erlenmeyer flasks, 3000 ml beakers, and 5 gal aquaria, all producing essentially the same results.2 These microecosystems included gravity-flow, calibrated 10 drop/min, 1000 ml flask continuous-flow systems for regular input of nutrients and similar gravity-flow bottom drained, screened outflow systems for removal of by-products, and continuous aeration to supplement the daily manual swirling for maintaining microbial dispersion and adequate exchange of gases. Saturation with dissolved O₂ and CO₂ duplicated the natural field conditions. Specially designed synthetic defined media with ion concentrations approximating the analyzed inorganic components and pH values for each Antarctic lake were used in our microecosystems (Table I).

All experiments, unless otherwise stated, employed: (a) autoclave-sterilized media; (b) regular microscopic monitoring of algal communities in stock cultures, inocula, and microecosystems; (c) experiments run in each of the three sizes of microecosystems in the same growth chamber, twice in triplicate with 600 and 3000 ml containers and once in duplicate with 5 gal aquaria; (d) a physical environment of 5 ± 1 C and a 12 hr alternating light cycle of 8000 and 2000 lux intensity, approximating the observed Antarctic summer conditions; (e) standard inocula of 1.0 ml (40–60 individual algae: *Chlamydomonas*,

TABLE 1

Composition of defined media for laboratory Antarctic microecosystems*

Chemical	Calculated Concentrations (mg/l, or as stated)				
Formula	Lake no. 1	Lake no. 2			
Na ₂ CO ₃	18.0	13.45			
$MgCl_2$	5.2	11.1			
Na ₂ SiO ₃	2.3	3.05			
H ₂ SO ₄ (1:1000 dil)	2.5 ml	3.47 ml			
HCl (1:1000 dil)	1.5 ml	1.5 ml			
FeCl ₂	0.417	0.417			
MnCl ₂	0.410	0.410			
Na ₂ HPO ₄	0.14	6.4			
Ca(OH) ₂	8.0	_			
KCl	2.2	_			
HNO ₃ (1:1000 dil)	2.5	_			
NH ₄ Cl	0.25				
CaCl ₂	_	27.7			
NH ₄ NO ₃		10.0			
NaNO ₂		2.01			
KHCO ₃		2.6			
рН	6.4	6.3			

* Add the following compounds per liter: H_3BO_3 , 1 mg; $ZnSO_4$: $7H_2O$, 1 mg; $CoCl_2$, 0.2 mg; Cu_2SO_4 , 0.04 mg; MoO_3 , 0.04 mg. This solution is based on analyses of trace elements in Lake Bonney, Antarctica (15). Na^+ , CO_3^- , Mn^{++} , K^+ , and the composition of this trace element mix are the only components not analyzed in the two freshwater environments. Na^+ , K^+ , and Mn^{++} were adjusted to levels found in other Antarctic lakes (16).

Chroococcus and Chlorella) of lake no. 1 community stock culture and 0.2 ml (50–80 individual algae: Chlamydomonas, Oscillatoria, Chroococcus and Chlorella) of lake no. 2 community stock culture per 500 ml in 600 ml flasks. As noted previously, these partial algal communities comprised the dominant algal genera found in both nanno- net-plankton collections from the lakes. The inoculum size for each community had been preadjusted to yield microecosystem productivity values after two weeks which approximated those obtained in our 1969–70 field studies. Microecosystems were allowed an average of two weeks for equilibration. Routine chemical analyses were made at 5-day intervals with the Hach DR-EL kit and accessories and preceded all primary productivity determinations.

Low phytoplankton densities and perpetual oxygen saturation of both these natural lakes led to our choice of the sensitive *in situ* 14 C primary productivity method of Steeman-Nielsen, with modifications by other workers, as detailed previously (2). We adapted this field method to our laboratory studies by using duplicate 70 ml screw-cap pharmaceutical bottles filled with aliquots from the appropriate microecosystem, then enriched with 4μ Ci of 14 C-sodium carbonate, and incubated adjacent to the microecosystems in the growth chamber. Microscopic counting of the algae in triplicate 1 ml samples from each system were made weekly throughout the experiments

The first series of experiments involved microecosystems for lake no. 1 with continuous dropwise

 $^{^2}$ 3000 ml beaker microecosystems consistently yielded primary productivity values about twice that of other containers, but the trends were identical and variations among replicates were ${<}10\%$.

input of single, select chemical components at rates predetermined to establish and maintain the approximate concentrations of these components to the levels found in lake no. 2 during the 1969–70 field scason. These were: phosphate-P (1.7 mg/l, as Na₂HPO₄), ammonium-N (2.5 mg/l, as NH₂Cl), chloride (35 mg/l, as MgCl₂ + 1.15 ml of 1:1000 conc. HCl), nitrate-N (1.75 ml/l of 1:1000 conc. HNO₃), and silicate (1.5 mg/l, as NaSiO₃); these additions produced minimal (\leq 10%) changes in pH. Following two experiments in different sized microecosystems, we ran one in which separate chemicals were added only initially during the two-week equilibration period to evaluate the rates of depletion of ions from the media.

In a second series of experiments, we enriched both lake microecosystems with iron (as FeCl₂) to ascertain whether the low levels detected in both natural lakes were limiting to primary productivity. Concentrations of 0.1 and 1.0 mg/l Fe⁺⁺ were ultilized and the results followed for 30 days in both 600 ml flask and 3000 ml beaker microecosystems.

A third experimental series tested combinations of nutrients added to lake no. I microecosystems: phosphate + nitrate, phosphate + chloride, phosphate + silicate, phosphate + ammonium, phosphate + nitrate + ammonium, nitrate + chloride, ammonium + silicate, using concentrations and compounds previously cited for the separate enrichments. Analyses of these ions were made at 5-day intervals concurrently with primary productivity determinations.

Finally, experiments were conducted to ascertain the adaptabilities of the microbial communities of the two lakes to their reciprocal chemical environments. More specifically, we wanted to learn whether the generic differences between the two microbial communities might account for part of the observed differences in primary productivity. Lake no. 1 community was grown in lake no. 2 synthetic medium using only the 600 ml flasks. Reciprocally, lake no. 2 community was inoculated and grown in lake no. 1 medium. Other aspects of the microecosystems were the same as for previous experiments.

Because our data showed similar trends in all three microecosystem sizes and the replicates for each experiment differed by only $\leq 10\%$, we shall report here only one set of representative data from the 600 ml flask microecosystems.

Following the simulated microecosystem experiments at VPI & SU, parallel field experiments were conducted during the 1970–71 season. Transparent plastic cylinders 8 inches in diameter and 3 feet long (open at both ends) were placed in both lakes, thereby delimiting representative water columns. Each cylinder contained approximately 10 liters of lake water. Following a 10-day equilibration period, lake no. 1 cylinders were then enriched generally at 5-day intervals with the same chemicals used in our laboratory work, each in quantities sufficient to approach the concentrations observed in the eutrophic lake no. 2 cylinder. The chemicals added were Na₂HPO₁ for PO—P enrichment, HNO₃ for NO₃—N enrichment and NH₄Cl for NH₄—N enrichment. Total

extractable chlorophyll and $C^{14}O_2$ fixation were measured *in situ* in the cylinders every 5 days, all by methods described previously (2).

Results

Separate Ion Enrichment Effects on Laboratory Microecosystems

The algal genera of both community stock cultures remained the same throughout the course of all microecosystem experiments with minor changes in population sizes. Similarly algae dominating in microecosystems were essentially the same as dominant algae identified in the respective natural lakes. Figure 1 reveals that the carbon uptake rates for synthetic lake no. 2 microecosystems were 5 to 10 times higher than that of unenriched lake no. 1 control microecosystems. The addition of ammonium chloride to lake no. 1 induced a sizable increase in primary productivity. Sodium phosphate also slightly stimulated productivity of the control lake no. 1 microecosystems, notably during the middle period of the experiments. However, additions of calcium chloride, sodium silicate, dilute nitric acid, and ferrous chloride (Fig. 1 and 2) did not enhance carbon

uptake rates in any of our experiments.

Figure 3 reveals the rates of nutrient depletion in microecosystems which received only initial separate ion enrichments. The best fit line analysis to the 0-30 day data using linear regression and the hypothesis of zero slope was rejected at p = .001 in every case. Total dissolved phosphate dropped to the original value of 0.1 ppm (as PO₄) in lake no. 1, while the concentration of phosphate in lake no. 2 fell to 0.8 ppm during the same 30 day period. The slopes of phosphate consumption during this 30 day period indicate an average rate for phosphate removal of approximately 0.15 ppm PO₄/day for both microccosystems. Similar trends in ammonium ion depletion occurred, but the concentrations of this ion remained somewhat higher in lake no. 1 microecosystems after initial enrichment than in lake no. 2. Average ammonium consumption for lake no. 2 microccosystems was 0.071 ppm NH_4 –N/day, while lake no. 1 consumed 0.064 ppm NH_4 –N/day, based on the respective 30 day curve slopes. Contrastingly nitrate depletion rates were only 0.005 ppm NO₃-N/day in both microccosystems. The concentrations of iron, dissolved silicate, and chloride are omitted from Figure 3 because they exhibited no detectable change during any of the depletion experiments.

Figure 4 shows carbon fixation rates for the nutrient depletion experiments of both microecosystems run in parallel with analyses shown in Figure 3. The initial separate enrichments with ammonium chloride and perhaps sodium phosphate produced stimulatory effects comparable to the continuous-flow experiments (Fig. 1) but with carbon uptake rates declining during the latter part of the

experimental period.

Combined Ion Enrichment Effects on Laboratory Microecosystems

Greatest stimulation of the carbon uptake rate occurred when ammonium chloride and sodium phos-

Fig. 1–5—Histograms showing primary productivity for simulated Antarctic lake nos. 1 and 2 microecosystems, variously treated. Data at 5-day intervals for 30, 35, or 40 days as further described in text.

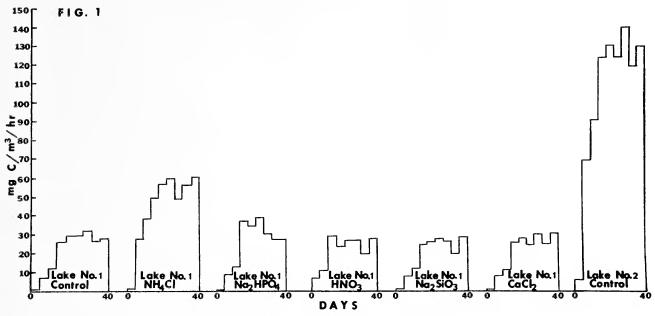


Fig. 1—Lake no. 1 microecosystems enriched separately and continuously with NH₄+, PO₄=, NO₃-, SiO₃= and Ca⁺⁺ to approximate ion concentrations in lake no. 2 microecosystems.

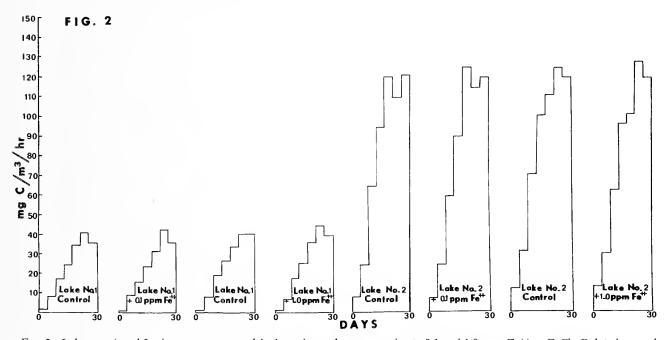


Fig. 2—Lake nos. 1 and 2 microecosystems enriched continuously to approximate 0.1 and 1.0 ppm Fe⁺⁺ as FeCl₂. Related controls are at left of each comparable histogram.

phate were combined, with and without nitrate, as enrichments to lake no. 1 microecosystems (Fig. 5). In these instances the levels of productivity approached those of lake no. 2 microecosystems during the latter part of the experimental period. Lesser enhancements were induced by additions of ammonium chloride plus calcium chloride, but little or no stimulation of carbon uptake occurred with other nutrient combinations. In all experiments employing

continuous-flow vessels, dissolved ion levels remained relatively constant throughout the experiments.

Community Structure Experiments in Laboratory Microecosystems

Figure 6 reveals that following the equilibration period, lake no. 1 microbial community in lake no. 2 medium reached about 3 times the productivity of the lake no. 2 microbial community in lake no. 1

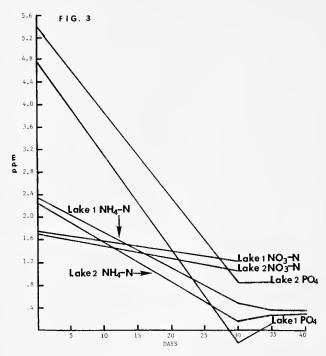


Fig. 3—Depletion of ions in lake no. 2 and separately enriched lake no. 1 microecosystems comparable to those in Fig. 4.

medium. After six weeks, the carbon uptake rates of lake no. 1 communities in lake no. 2 media nearly equaled those for the control replicates involving lake no. 2 media with its native microbial community. Conversely the carbon uptake rates of lake no. 2 community in lake no. 1 medium barely approached the productivity in lake no. 1 control.

1970–71 Field Cylinder Experiments

Figures 7 and 8 reveal also, that in situ cylinder enrichment of lake no. 1 water with ammonium chloride stimulated phytoplankton carbon fixation and chlorophyll production in excess of that caused by sodium phosphate enrichment and in considerable excess of the control unenriched cylinder. In situ cylinder enrichment of lake no. 1 water with ammonium chloride + sodium phosphate produced the greatest overall stimulation of phytoplankton productivity as indicated by the total areas under the graphs. The only trend not consistent between the laboratory and field experiments occurred when HNO₃ was added to lake no. 1 water in cylinders, resulting in an increase in productivity over the control. This degree of stimulation was not observed in the laboratory microecosystems.

Discussion

Our laboratory microecosystem studies suggest that ammonium ion is a major single nutrient limiting the level of primary productivity in lake no. 1 microecosystems. Phosphate is of lesser importance, inducing a smaller stimulation of primary productivity in the simulated laboratory microecosystems. A greater stimulation by phosphate might have been

anticipated from the high ratio of inorganic nitrogen to orthophosphate-phosphorus in lake no. 1 (28:1), as compared with lake no. 2 (3:1) microecosystems.

Similar results were obtained in the 1970–71 field cylinder studies. Concentrations of PO₄–P and NH₄–N to a lesser degree NO₃–N were significantly higher in lake no. 1 during the second field season (Samsel and Parker, unpublished). These differences may explain the less pronounced stimulation of productivity in the enriched cylinders as compared with the laboratory microecosystems which simulated the chemical composition of the lakes during the earlier 1969–70 field season.

The microecosystem studies showed that ammonium chloride and sodium phosphate in combination induced even higher productivity rates than when added separately. Carbon uptake approached, and in one instance reached, the level of the control lake no. 2 microecosystem when these two salts were added to lake no. 1 laboratory microecesystems. In contrast, additions of salts containing iron, chloride, silicate, nitrate (HNO₃), and changes in pH (not shown here) induced no detectable changes in productivity of lake no. 1 microecosystems; furthermore, these ions were not removed from solution to any significant degree as compared with the non-depleted microecosystem experiments (Fig. 1). The data in Figure 3 and linear regression analysis indicate a high level of significance for a relatively constant rate of removal of ammonium and phosphate from both lakes microecosystems during the initial 30 days. After 30 days, uptake ceased. This cessation of phosphate uptake at a higher external concentration in lake no. 2 than in lake no. 1 microecosystem probably is due to limiting ammonia nitrogen. This point further supports our conclusion that ammonium is the major nutrient inducing the productivity differences between the two microecosystems. We are not certain why the ratios of NH₄-N/P removal in our depletion experiments were as high as 0.7-0.8 unless luxury consumption of phosphate occurred by both algal communities or perhaps some phosphate was precipitated and adhered to the glass surfaces.

Our laboratory microecosystem studies support the suggestion made earlier by us (1, 2) that these two natural Antarctic lakes differ in their primary productivity, extractable chlorophyll, and species diversity chiefly as a result of differences in ammonium ion and to a lesser degree phosphate. Silicate, chloride, and nitrate do not appear to limit algal productivity in the laboratory microecosystems nor is iron generally limiting in either lake. Kalff (17) working on arctic tundra ponds likewise found ammonium ion to be the critical limiting factor for phytoplankton productivity.

Of special interest is the inability of nitrate additions to stimulate productivity and its relatively slow removal rate from the laboratory media. This inability of nitrate to produce increases in productivity in the microecosystems did not prevail in our field cylinder studies. As far as we are aware no environmental feature of our microecosystems would have inhibited nitrate reduction in the algal community. The synthetic media (Table I) included molybdenum

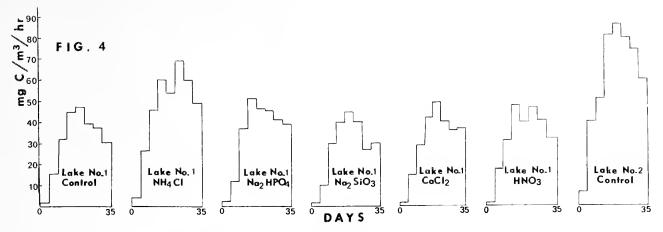


Fig. 4—Like Fig. 1 but with a single, initial enrichment at Day 0.

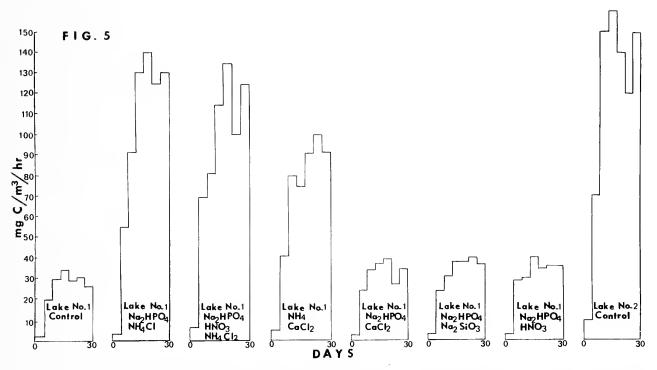


Fig. 5—Lake no. 1 microecosystems enriched continuously with NH₄⁺, PO₄⁼, NO₃⁻, SiO₃⁼, and Ca⁺⁺ in various combinations to approximate respective ion concentrations in lake no. 2 microecosystems.

in the trace element mix; furthermore, other known requirements for near optimum nitrate reductase activity (i.e., other ions—phosphate, silicate, sulfate, etc; pH; low respiration rates, light, dissolved O₂ and CO₂), as cited by Kessler (6), were present in both laboratory and field. We have examined the possibility that ammonia may repress nitrate reductase formation by measuring carbon uptake in lakes 1 and 2 laboratory microecosystems lacking ammonium; after 30 days, no stimulation of productivity occurred. We therefore suggest the tentative conclusion that nitrate reductive systems may be genetically lacking or poorly developed in the algae represented in our culturable partial communities.

In contrast, the more complete community of the cylinders, which included phytoplankton and attached organisms, may be more capable of nitrate utilization. Conclusive proof of these possibilities, however, awaits further experimentation.

Although the partial algal communities of these two Antarctic lakes differed appreciably (biomass, species diversity, different species), neither partial community used in our laboratory microecosystem studies differed in dominant algae observed in the natural lakes during both seasons. Neither did either of the partial communities appear markedly better adapted than the other for nutrient comsumption and utilization on the basis of chemical composition data

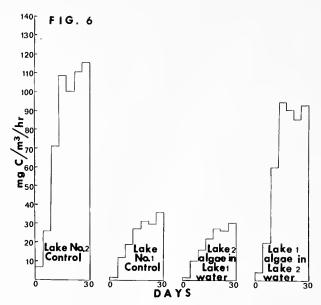


Fig. 6—Lake nos. 1 and 2 microecosystem environments reciprocally inoculated with each other's partial microbial community.

for the laboratory microecosystems, allowing of course a suitable period for acclimation. However, lake no. 1 partial community consistently revealed lower initial carbon uptake rates than lake no. 2 community when both communities were grown in lake no. 2 simulated medium.

Our laboratory microecosystem data show some fluctuations in carbon uptake which may stem from

diurnal rhythms. The use of triplicate samples with low variability and repeat experiments and different size microecosystems with the attainment of the same trends suggests that these fluctuations in carbon uptake observed at 5-day intervals are not due to statistical error. Furthermore, these fluctuations represent photosynthetic carbon uptake because dark bottle controls never revealed over 3–4% of the light bottle values. Similar fluctuations occurred in the field cylinder data.

The use of culture techniques and laboratory aquatic simulated ecosystems for determining primary productivity relations, metabolism values, and the availability of nutrients for algal growth has been recognized for several years. Odum and Hoskin (7), Ryther and Guillard (8), McConnell (9), Whittaker (10), Beyers (11), and Bozniak (12), have used such artificial microecosystem techniques. However to our knowledge, we are the first to use defined media specifically aimed at simulating the inorganic composition of the natural water in our laboratory microecosystems. Also few previous investigators have employed a variety of containers in order to identify container effects on primary productivity rates in closed microecosystems (12) or have used continuous-flow devices and continuous and periodic shaking of experimental microecosystems (13, 14). Admittedly, the artificial media used in our tests only approximated the inorganic chemical composition of lakes 1 and 2, including pH, oxygen and carbon dioxide values, and these approximations applied only to the 1969-70 field season. Also, organic additions were omitted although significant differences in the total dissolved organic matter oc-

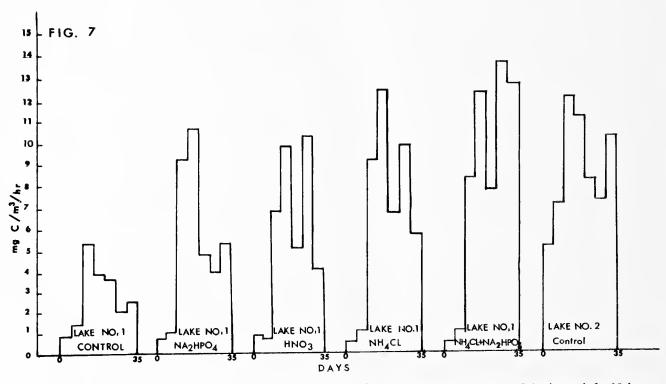


Fig. 7—Primary productivity resulting from in situ cylinder enrichment in lake no. 1 (1970–71). Data at 5-day intervals for 35 days.

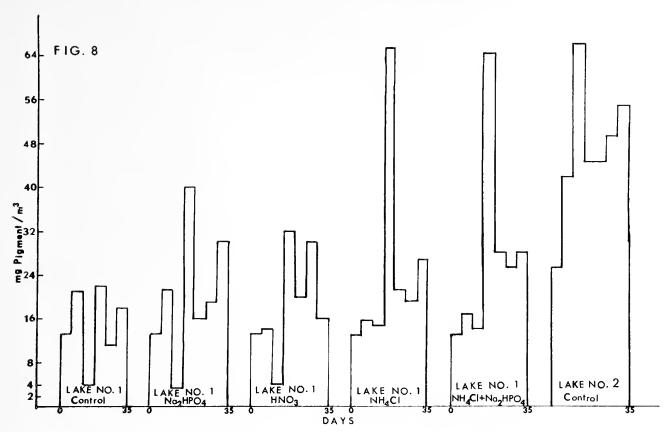


Fig. 8—Primary productivity (total extractable chlorophyll) from in situ cylinder enrichment in lake no. 1 (1970–71). Data at 5-day intervals for 35 days.

curred between both natural lakes. We recognize the inherent artificiality of simulated laboratory aquatic ecosystems, but feel that our methods have enabled a limited integration of laboratory and field data aimed at identifying and confirming the factors which limit the productivity of aquatic eommunities. This con-

clusion is supported also by the field eylinder data. We must emphasize that laboratory microecosystems represent only simplified models for studying certain processes which may operate naturally. Such model systems offer special potential for supplementing one's knowledge of remote aquatic ecosystems which do not lend themselves to the usual yearround, comprehensive field investigations. The results of our laboratory studies comparing Antarctic lakes 1 and 2 have not only confirmed the suggestion made earlier that the ammonium ion concentration is a factor of major ecological significance eausing the productivity differences observed in the field, but also have enabled our more efficient design of experiments for future, necessarily brief visits to these freshwater habitats during Antarctic summers.

Acknowledgments

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Lake Drummond of the Dismal Swamp: I. Phytoplankton Composition*

Abstract—The seasonal composition and fluctuation of phytoplankton populations for Lake Drummond are discussed for a one-year period. The predominant plankton flora consisted of diatoms, with Asterionella formosa the dominant species. Seasonal variations in oxygen, pH, temperature, depth, visibility, and chlorophyll values are also

presented for Lake Drummond.

Lake Drummond is located near the center of the Dismal Swamp in southeastern Virginia. It is 4-5 km in diameter, occupies an area of approximately 13 sq km and has a depth up to 2 meters. The lake water is acid year round and stained a tea brown color. The color is the product of rain water seepage through the surrounding peat deposits in the drainage basin. As this water drains toward the lake, it leaches out of the peat various humie colloids which impart the characteristic color.

The age of the lake has been estimated by Whitehead (1) to be about 4210 (\pm 160) years old. This was determined by pollen analysis and radiocarbon dating of the basal clay in the lake basin. Further investigations of swamp peat by radiocarbon dating determined the oldest collected sample to be estimated at 8900 years old, indicating a more recent origin for Lake Drummond than the Dismal

Swamp (1).

The hydrography of Dismal Swamp has been discussed by Ramsey, Hinkle, and Benander (2). The northern part of the swamp drains into the James River, with the southern portion entering the Pasquotank and Northwest Rivers. Most of the central and western portion of the Dismal Swamp drains into Lake Drummond. This occurs by natural surface flow patterns and man-made ditches, notably the Washington and Jericho ditches from the northeast. The oldest of these ditches, Washington ditch, dates back to the 1760s, when it was constructed to transport logs out of the swamp.

The flow of water out of Lake Drummond is mainly through the feeder ditch connecting the lake with the Dismal Swamp canal. This canal was surveyed by George Washington and completed in 1805.

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Its purpose was to provide a link between the Southern Branch of the Elizabeth River and the Pasquotank. In order to maintain adequate water level in the canal, a feeder ditch to Lake Drummond was dug in 1812. The flow from the lake through the feeder ditch is controlled by a spillway operated by the U. S. Army Corps of Engineers. It is not possible for the lake to be completely drained via the spillway, because the ditch does not connect to the deepest portion of the lake basin. The normal level of Lake Drummond is 17 feet above mean sea level. Since May 1926 the highest recorded value was 18.8 feet in October 1956 (U. S. Army Corps of Engineers' records). The lowest value, 11.5 feet, occurred in autumn 1952 when the lake shrank close to small pond proportion after a long drought. Annually, under normal weather conditions, the water level is lower in summer and autumn than it is in winter and spring, when there is less evaporation and precipitation increases. The present paper concerns a 13month study of the phytoplankton composition in Lake Drummond. Earlier reports on the phytoplankton in these waters have been made by Marshall and Poore (3, 4), and Poore (5).

Methods

Two stations were established in Lake Drummond as collection sites. One was on the eastern margin about 100 meters from shore, the other was more centrally located in the lake (Fig. 1). Twenty four water samples were taken at approximately bimonthly intervals from June 1970 through June 1971. The samples were taken at the surface and 15 cm above the substrate at these two stations.

Water samples were taken with a 2 liter Kemmerer water bottle. A 500 ml sample was transferred to a bottle for plankton analysis, and preserved immediately with a modified Lugol's solution consisting of I₂-KI-acetie acid (6). After a settling period of two weeks, the supernatant liquid was siphoned to obtain a 30-40 ml concentrate. A 0.1 ml portion of the concentrate was placed in a Palmer-Maloney counting cell and examined with an AO Spencer phase contrast microscope. To assure greater ac-

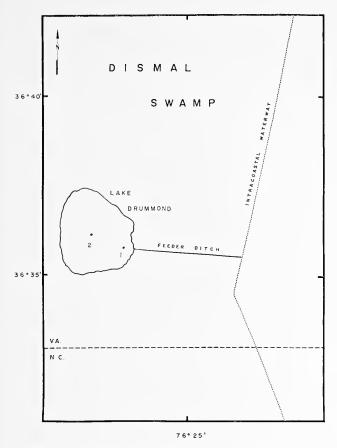


Fig. 1—Location of stations in Lake Drummond and the relation of the feeder ditch from the lake to the intercoastal waterway (Dismal Swamp Canal).

curacy 2–4 aliquots from each sample were examined. The phytoplankton quantities were expressed as the number of cells per liter.

Additional water samples were taken at each station for chlorophyll determinations. A millipore apparatus, with MP filter (HA 0.8 microns) was used to concentrate the phytoplankton contained in 1 liter of water. Chlorophyll extraction and spectrophotometric procedures were followed as outlined by Strictland and Parsons (7). The pH was determined with a Beckman Model 180 pH meter. A reversing thermometer was used to obtain the temperature, a secchi disc for visibility, and a modified Winkler technique used for oxygen values. Additional nutrient and chemical analyses of the lake water were obtained through the courtesy of Mr. W. P. Taylor of Charles T. Main, Inc.

Results

Physical and chemical conditions

The climate of the Dismal Swamp region is strongly influenced by its close proximity to the Atlantic Ocean and the Gulf Stream which offer protective high humidities and high temperatures. The summers are long and humid, with the winters mild. Annual precipitation is about 48 inches per year with only slight snowfall. Due to the shallow nature of the lake,

the water temperature remained fairly constant with depth throughout the study. There was no evidence of a thermocline. The shallow conditions and windswept surface contributed to repeated periods of turnover and mixing of the lake waters. Stations 1 and 2 were about 2 km apart but little difference in the physical and chemical nature was apparent during the study.

The pH range for the lake was 3.2 to 5.0. Lowest values were recorded in September, with the highest point reached in the summer months. Generally, the values fluctuated between 4.0 and 4.4, with both stations having a yearly average of 4.3. The high acidic nature of these waters may be considered influenced by the swamp drainage patterns into the lake. The leeching effect of various organic acids from the surrounding peat deposits, plus the decomposition products from the lake would tend to maintain the acidic nature of the lake. In addition, acidity may be enhanced by the formation of H₂SO₄, as described by Frey (8) for some of the bay lakes in North Carolina. Nutrient and mineral levels for the lake during August and September 1970 indicated low nutrient concentrations, with a total hardness of 30 ppm (9). Calcium carbonate and magnesium carbonate each contributed 15 ppm of this amount. The lake water was very turbid throughout the study, apparently a product of the mixing effect of the wind action. Secchi disc readings of 8-12 cm occurred during low lake levels from October to December, with readings up to 64 cm noted during high lake levels in April and May (Fig. 2). These minimal and maximal visibility ranges were inversely related to chlorophyll and phytoplankton concentrations (Fig. 2). Higher concentrations of oxygen occurred during the colder months and directly after a heavy rainfall, or strong wind agitation to the lake surface. Oxygen values at the surface were usually slightly higher than bottom waters with the concentrations generally between 50 and 90% saturation. The oxygen range for the time period was from a low of 3.32 to a winter high of 8.68 ml/liter.

The lake level fluctuated considerably throughout the year, with an average range of 119 cm at both stations. This degree of magnitude is not uncommon to the lake. Kearney (10) reported the greatest depth of the lake prior to the construction of the feeder ditch to the Dismal Swamp Canal to be about 4.5 m. In November 1898, the depth was reported by Kearney to be considerably less than 2 m in every part of the lake. Army Corps of Engineers records dating back to 1952 indicate the lake level fluctuates normally 1 meter yearly, depending on the amount of precipitation and drainage through the spillway into the feeder ditch. Higher levels occur during the winter and spring seasons, with low water common during the summer and fall. During periods of low lake level, jagged stumps and fallen logs are uncovered around the lake periphery. At station 2, depth readings declined from 200 cm on 22 June 1970 to 78 cm on 9 December 1970. Winter rains followed and the lake level rose 122 cm in the following three month period to 200 cm on 10 March 1971. This level remained fairly constant for the next 5 months.

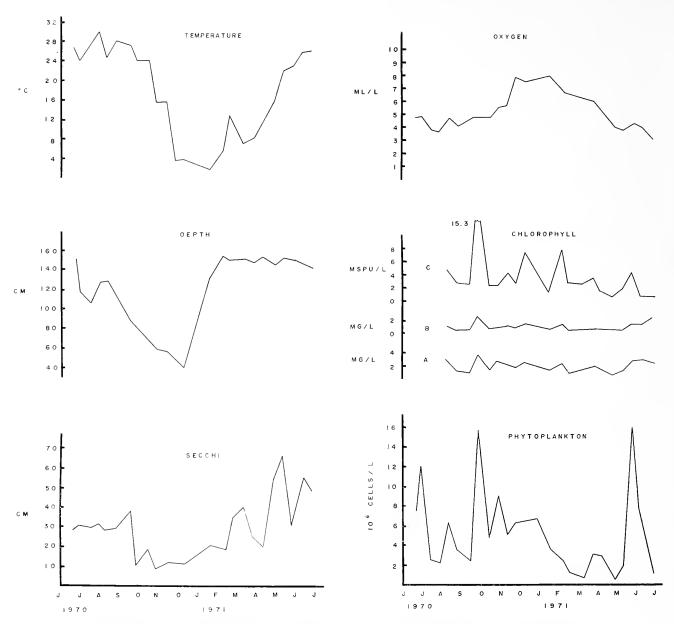


Fig. 2—Environmental data obtained from Lake Drummond, at Station 2, between June 1970 and July 1971.

Phytoplankton

A total of 30 phytoplankters were identified with 19 classified to species and 11 identified to genera (Table I). No attempt was made for a complete taxonomic analysis of the lake algae. There were 17 chlorophyceans present, with Ankistrodesmus falcatus, Scenedesmus opoliensis, and the desmids Closterium gracile and Staurastrum paradoxum predominant species. The filamentous green algae contributed little to the phytoplankton, with Microspora pachyderma the most common form. The diatoms represented the most abundant plankton flora of Lake Drummond. Of the 10 noted species the dominant form was Asterionella formosa. Large concentrations of this species occurred throughout the year, reaching bloom conditions of over 10

million cells per liter in the months of May, June, and September (Fig. 3). Its lowest numbers were recorded at 300,000 cells/l in April 1971. Other common diatoms included *Synedra radians, Pinnularia acuminata*, and *Melosira Herzogii*. The dinoflagellates were present sporadically throughout the study, with the Euglenophyta and Cyanophyta uncommon. Other constituents of the phytoplankton were two *Cryptomonas* species. These and several unidentified flagellate forms were frequently observed and most common in the summer months.

Seasonal phytoplankton distribution

The monthly concentrations for the phytoplankton groups in Lake Drummond are given in Table II. There was a basic bimodal pattern within which occurred numerous pulses indicative of periods of

TABLE I

Phytoplankton observed in Lake Drummond

Chrysophyta Bacillariophyceae Asterionella formosa Hassal Eunotia curvata (Kutz) Lagerheim Melosira Herzogii Lemin Meridion sp. Agardh Pinnularia acuminata W. Sm. Pinnularia lata (Breb.) Rabh. Synedra acus Kutz Synedra radians Kutz Chrysophyceae Dinobryon sertularia Ehrenberg Symura sp. Ehrenberg Chlorophyta Chlorophyceae Aukistrodesums falcatus (A. Brown) G. S. West Coelastrum cambricum Archer Coelastrum sp. Naegeli Dictyosphaerium Ehrenbergianum Naegeli Microspora pachyderma (Wille) Lagerheim

varied growth by the individual phytoplankton components. Major growth periods occurred during the fall months of 1970, that subsided gradually into winter with the lowest concentrations delayed until early spring. This was followed by a bloom period

Mougeotia sp. (C.A. Agardh) Whittrock Oedogonium sp. Link Oocystis Borgei Snow Scenedesmus quadricanda (Turp.) de Biebisson Scenedesmus opoliensis P. Richter Scenedesmus sp. Meyen *Ulothrix* sp. Kuetzing Desmideaceae Arthrodesmus triangularis Closterium gracile Brebisson Desmidium baileyi (Ralfs) Nordstedt Netrium sp. Naegeli Staurastrum paradoxum W. West Euglenophyta Euglenophyceae Phacus sp. Dujardin Cyanophyta Myxophyceae Spirulina Nordstedtii Gomont Pyrrhophyta Cryptophyceae Cryptomonas sp. 1 Ehrenberg Cryptomonas sp. 2 Ehrenberg

in late spring and early summer. This bimodal pattern of phytoplankton concentrations was not the product of simultaneous fluctuations of all species present in the lake, but rather the result of population densities of *Asterionella formosa*. In Lake Drum-

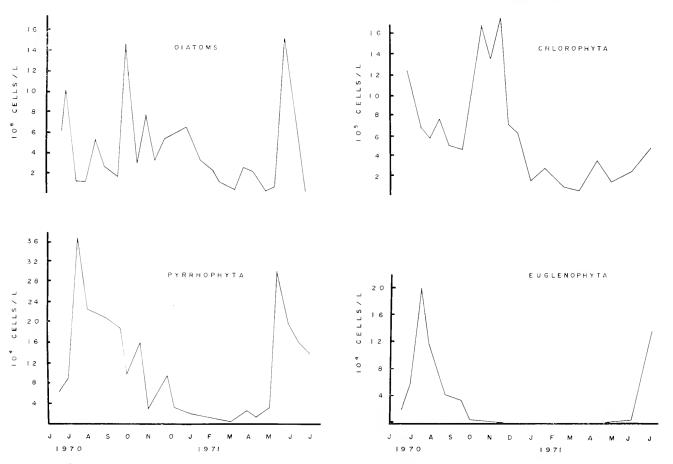


Fig. 3—Distribution patterns of the major phytoplankton observed at Station 2 in Lake Drummond between June 1970 and July 1971.

TABLE II

Averages of total phytoplankton according to algal groups for all stations in number of cells per liter (x10²)

Data	Phytoplankton							
Date 1970–71	Chloro.	Diat.	Pyrrho.	Eugleno.	Cyano.			
June 22	12759	61143	771	328	_			
June 30	11291	107481	900	580	_			
July 14	6863	12310	3745	2013	_			
July 28	5744	12294	2146	1158	_			
Aug. 11	7668	52704	2107	796				
Aug. 26	4974	27213	2073	405	_			
Sept. 16	4756	17880	1836	330	_			
Sept. 28	9849	146176	954	40	_			
Oct. 14	16878	29793	1611	30	_			
Oct. 28	13737	76677	285	3	_			
Nov. 12	17336	32488	656	_				
Nov. 24	7094	53404	980	-	4			
Dec. 9	6263	58416	360	-	_			
Dec. 30	1472	66288	216	_	-			
Jan. 19	3260	32504	124	_	4			
Feb. 8	1608	23224	76	-	_			
Feb. 18	976	11080	120		_			
Mar. 10	640	6640	108		4			
Mar. 24	1700	28324	260	_	***			
Apr. 7	3412	23509	144	_				
Apr. 28	1380	4328	308	_	_			
May 10	1692	8720	3060	4	_			
May 26	2216	151940	2092	20	4			
June 11	3668	69688	1600	740				
June 25	4428	4812	1404	1352	_			

mond, the Euglenophyta flourished in the summer, Pyrrhophyta in late spring and summer, Chlorophyta in early summer and fall, and diatoms abundant year round (Figs. 2, 3). These results differ from those of Whitford (11) who found, in brown water lakes of the coastal plain, chlorophyceae to be abundant in late spring, diatoms in late summer, and chrysophyceae in winter.

Summary

Lake Drummond should be recognized as a unique body of water with distinct characteristics and biota. It may be characterized as follows: it is a temperate, freshwater lake, medium in size; protected by a surrounding swamp forest, but is large enough to possess a wind swept surface; the depth is shallow and fluctuates seasonally; there are man-made drainage ditches; the water is acidic, stained, and very turbid; there are stagnation zones, mucky and sandy bottoms, and few vegetation beds; thermal stratification does not exist seasonally, but incipient stratification might develop; it has low nutrient levels; and supports a predominant diatomaceous plankton flora with slight diversity of species.

The bulk of the phytoplankton was a combination of diatoms, chlorophyceans, and phytoflagellates. The dominant species was the diatom *Asterionella formosa*. The general seasonal distribution pattern of total phytoplankton followed a bimodal curve of population density.

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Especially for Science and Mathematics Teachers

Ideas Questions Opinions

DENSITY: A LABORATORY EXERCISE

Density and specific gravity are physical properties easily determined by nondestructive procedures.

Density = $\frac{\text{Mass/Volume}}{\text{Density of a substance}}$ Specific Gravity = $\frac{\text{Density of a substance}}{\text{Density of a standard}}$

For solids and liquids, mass is generally in grams and volume is in cm³. Since density varies with temperature, for exact work the temperature of the substance must be stated. For example, the density of antimony is given in a table as 6.684^{25} which means 6.684 g/cm³ at 25° C.

Sometimes the average density of a mixture is required. In this case, the *total* mass is divided by the *total* volume.

In this experiment the density of a solid, the density of water, the average density of a solid-water system and the density of a salt solution will be determined.

Experimental

I. Density of a Solid*: If the sample is a regular solid, determine the dimensions and calculate the volume. Determine the mass of the solid on a balance giving 3 significant figures. Calculate the density.

II. Density of Water: Weigh a clean dry 100 or 150 cm³ beaker and watch glass to fit. Using a 100 cm³ graduated cylinder, measure as exactly as possible 50.0 cm³ of water. Transfer the water to the beaker, cover, and weigh again. Save for part III. Determine the temperature of the water. Calculate the density.

III. Average Density of a Mixture: Carefully slide the solid (from part I) down the side of the 100 cm³ graduated cylinder. Add the 50 cm³ of water from the beaker and read the total volume. How does this compare with the sum of the individual volumes? Calculate the average density of the mixture, the % by weight of the solid and the % by volume of the solid in the mixture.

IV. Density of a Salt Solution: Weigh a clean dry 100 or 150 cm³ beaker. Add 25.0 ± 0.1 g of anhydrous calcium chloride. Add 75.0 ± 0.5 cm³ of water. Dissolve by stirring. Is the beaker getting hot or cold? If hot, it indicates that the process of solu-

* Solids that have been found satisfactory are cylinders of steel, aluminum, copper and brass.

tion gives off heat (reaction is exothermic). If the beaker is cold it means that the process absorbs heat (reaction is endothermic). Is the dissolving of anhydrous calcium chloride in water endothermic or exothermic? When the solution is at room temperature pour it into a 100 cm³ graduated cylinder and read the volume to 0.5 cm³. Calculate the density of your solution using 75 g as the mass of the water. Check your result with that in a handbook for the density of calcium chloride solution of the percentage composition equal to the one you prepared. If available, use a hydrometer of the battery acid type to determine the density of your calcium chloride solution and compare the result with that previously obtained.

Using the density of anhydrous calcium chloride as 2.15 g/cm³, calculate the volume of the solid calcium chloride used in this experiment. Note that this volume plus the volume of water does not equal the volume of the solution. In other words, the volume of a solution does not necessarily equal the sum of the volumes of the components.

Problems

A brass cylinder is 4.57 cm in diameter and 2.16 cm high. It weighs 286 g. Calculate its density in g/cm³. (3 significant figures)

2. A steel cylinder weighing 238 g is 3.80 cm in diameter and 2.70 cm high. Calculate the density.

3. A copper cylinder weighing 89.2 g has a diameter equal to its height. Calculate the diameter if the density of copper is 8.92 g/cm³.

4. To 100 cm³ of water (d = 1.00 g/cm³) are added 100 g of sand (d = 2.66 g/cm³). Calculate (a) the average density of the mixture, (b) the percentage by weight of the water and (c) the percentage by volume of the water in the mixture.

5. A mixture of silver and copper pellets (all pellets identical in size) has a density of 9.71 g/cm³. Calculate (a) the percentage by weight and (b) the percentage by number (volume) of pellets of copper in the mixture. D. of copper = 8.92 g/cm³; D. of silver = 10.50 g/cm³.

6. When 256.2 grams of ammonium chloride are dissolved in 811 grams (811 cm³) of water a solution is obtained having a density of 1.067 g/cm³. The density of ammonium chloride itself is 1.53 g/cm³. Calculate (a) the % by weight of ammonium chloride in the solution, (b) the volume of the solution, (c) the volume of the solid ammonium chloride, and (d) the sum of the volumes of the solid NH₄Cl and the added water.

7. The density of an aqueous sulfuric acid solution at 20° C varies with the % by weight of H₂SO₄ as follows:

D(g/cm³)	%H ₂ SO ₄	D(g/cm³)	%H ₂ SO ₄
1.000	0	1.779	85
1.032	5	1.814	90
1.066	10	1.828	93
1.139	20	1.831	94
1.219	30	1.834	95
1.303	40	1.8355	96
1.395	50	1.8364	97
1.500	60	1.8361	98
1.611	70	1.8342	99
1.727	80	1.8305	100

Plot a smooth curve of D vs % of H₂SO₄. Is it feasible to determine the concentration of an aqueous sulfuric acid solution by density alone in the range of 93-100% H₂SO₄? Why?

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TEACHING MODERN SCIENCE

By Arthur A. Carin and Robert B. Sund Charles E. Merrill Publishing Company Columbus, Ohio, 1970 273 pages, \$3.25

This paperback book is designed to prepare prospective and experienced teachers to use the discovery approach in teaching elementary school science. The authors believe that this method of learning is designed to allow the youngster to learn scientific principles in the same way that investigative patterns are carried out by a professional research scientist. Such an approach is not at all a new innovation but appears to have receded to the elementary school along with the teaching of science.

The first of the eleven chapters gives a working definition of science pointing out that teaching science through discovery should be consistent with both the process of teaching as well as the product of

teaching.

Teaching guides and suggestions are presented throughout the three main parts of the book: 1) Shaping Science Education in the Elementary School, 2) Organizing and Planning for Teaching-Learning Science Through Discovery, 3) Enrichment Activities for Discovery Science Teaching-Learning.

Of particular value and also found throughout the book are black and white photographs of children involved in experiments, or teachers working with the children. Each of these photographs has a question as the caption. These pictorial situations tend to suggest to the reader a variety of ideas for possible classroom use.

Each chapter concludes with a summary and a section on "Self-Evaluation and Further Study" which lists additional activities to be carried out by the teacher and also gives a listing of articles and books for reference.

A history of elementary school science is pre-

sented in Chapter Three showing the change in the past one hundred years due to social, economic, scientific, and technological advances. The presenta-

tion is not especially new or interesting.

The section on planning for discovery is quite short, only eighteen pages. However, it is suggested in this area that only six to eight broad science areas be presented yearly. This is based on their philosophy that the children will study these science areas in depth and their learning will be more meaningful and the percentage of retention higher. The unit structure of teaching science is also supported by the authors.

Laboratory "experiences" are divided into experiments and demonstrations with each defined. In elementary schools, classrooms may be used instead of the "laboratory" of a high school or college. A detailed list is given stating the usefulness and advantages of demonstrations, whether performed by the teacher or the student. With experiments, students are the participants rather than the observers and activity oriented experiments are stressed. Discovery demonstrations lessons are discussed and intended to encourage the student to reason from his observations rather than the teacher explaining it to him in lecture form. The book explains how to prcpare and the best approach to giving demonstrations. It also provides the basis to write and develop your own discovery laboratory lessons. This is in a ninestep outline. The authors support this approach in conjunction with the use of positive reinforcement by encouragement. Laboratory safety is also stressed.

The importance of effective science reading is pointed out. Participation and first hand experience are suggested repeatedly as the best means of learning science, but the value of reading as an integral but enriching part of science is not neglected.

The usefulness of machines such as the Bell and Howell "Language Master," the overhead projector, radio and television are noted in planning indoor discovery activities. Useful and appropriate suggestions are made for outdoor discovery activities, also.

A few, but very appropriate paragraphs deal with individualization in the science discovery method to the gifted students, the slow learners, Project Head Start children, mentally retarded children, and the blind. Some examples of school systems working with individualized science discovery programs are

listed and briefly discussed.

This book would be a very suitable acquisition for the professional library of an elementary school teacher, some junior high science teachers and even some kindergarten teachers. If it is not in their personal professional library, it definitely should be made available to them by their supervisor. Approximately 60 to 70 percent of the information would be of value to the experienced teacher.

The obvious strong point of the book is the emphasis of student involvement and in particular, the presentation of many very good "Enrichment Activities" equally concerned with the biological, chemical and physical sciences and written especially

for use by the elementary teacher.

—GERALD C. LLEWELLYN

Communications and Reports

VIRGINIA ACADEMY OF SCIENCE

Summary of Council Meeting*

April 9, 1972

Council was called to order at 11:45 a.m. in Room 114 of the University Center, Washington and Lee University, Lexington, Virginia, President Turner presiding.

Officers' Reports

President Turner accompanied President-elect Flint to the AAAS meetings in Philadelphia, December, 1971. The AAAS honored Dr. Wisman and Mr. Rodney Berry at a special banquet. Dr. Turner also spoke at the banquet meeting of the 47th Annual Meeting of the West Virginia Academy of Science, standing in for Dr. Stahr. Dr. Perry Holt and other members of the VAS gave papers at the meeting held at Bluefield State College. Dr. Turner suggests that we continue to think about ways in which the two academies can cooperate. Dr. Turner will represent the VAS at the inauguration of Superintendent Irby of VMI on April 15, 1972.

The President reported that Dr. Peter van de Kamp, an astronomer and Director of the Sproul Observatory will speak at the May, 1972, meeting on the search for extra-solar planets in our stellar neighborhood. Dr. Raymond Taylor will be the official representative to the VAS meeting from AAAS, as arranged by correspondence with Presi-

dent Turner.

President-elect Flint reported on meetings and correspondence with the Association of Academies of Science (AAS) and made two points which triggered much discussion: the dues of member academies will be raised from 2e per member to 5e per member; the new constitution is not yet in effect, but when it is operational we will no longer send representatives to their council, rather we will have an opportunity to present our nominees to the AAS for their elective procedures. Drs. Harshbarger and Siegel and Mr. Berry commented on the background and impact of these changes. Dr. Wisman favors withdrawal from AAS and AAAS. In response to the question "What are the benefits of membership?", it was revealed that the VAS receives \$1.00 per member of AAAS resident in Virginia. In 1971 this amounted to \$495; in 1972, \$520. The funds can be carried over to the next year if necessary. On motion by Dr. Harshbarger, seconded by Dr. Wisman, the Council requested the President appoint a committee to study our involvement with AAAS and report back to the Council, perhaps at its Fall meeting. Dr. Wisman suggested that an official delegate or officer from the Assn. of Academies be invited to

attend our annual meeting to resolve some of the

problems.

Dr. Flint further reported that the program for the May meeting had gone to press and would be distributed to early registrants. There are 354 papers scheduled for presentation in the VAS, including a presentation by an astronaut (Donn Eisele) and Congressman Downing in the Space Science and Technology Section. Dr. Hughes requested space and cooperation for an Environmental Symposium on Thursday morning at which state and national legislation relating to the environment would be discussed.

Dr. Carpenter reported that local arrangements for the annual meeting were progressing satisfactorily. He raised the question of requiring registration for students and faculty of the host institutions. After some discussion Council approved a motion by Paul Siegel (seconded by Lowry) that students of W & L and VMI be admitted to the paper sessions as guests of the Academy by showing their student identification cards. Good pre-meeting and meeting publicity is expected.

Reports of Standing Committees

The report of the Awards Committee (Dexter Whitehead, Chairman) was read in which eight names were offered for election to Fellow of the Academy, from a list of nominations of ten. Dr. Harshbarger moved that the eight names read by the President be accepted as Fellows, approved by voice vote. After the vote a question was raised about twenty nominees discussed by Council in 1971. Dr. Wisman moved (seconded by Carpenter) that future policy be that those duly nominated but not selected be carried over for one additional year. In the discussion the consensus was that late nominations for a given year would be carried over to the next year. Approved by voice vote. Dr. Bradley moved (seconded by Wisman) that the Executive Committee make a recommendation to the next meeting of Council on the feasibility of sending the names of nominees for Fellows directly to the Executive Secretary so that he might have a record of the nominations. Motion carried.

The Chairman of the *Finance and Endowment Committee* said that his report will come at the May meeting. On motion by Dr. Flint, Council approved the budget for 1971–72 as submitted by mail to Council.

Virginia Junior Academy of Science: Dr. Wisman reported that programs had been mailed out and voiced concern that physical support by the VAS might drop off, because of the separate site (Natural Bridge). About 272 papers were submitted, of which 194 were placed on the program. The May meeting conflicts with the International Science Fair in New Orleans and some papers may be withdrawn. Leslie Watkins reported that the 1973 meeting will be held

^{*}Abbreviated by the Editor from minutes provided by Leonard O. Morrow, acting for the Secretary, G. R. Brooks.

in San Diego May 6–11 which will not present conflicts. Gifts to the VJAS this year have totaled \$1,200

and another \$1,500 is expected.

Dr. Ulrich reported that the Long Range Planning Committee had not met this year, but it was concerned about the involvement of the staff and students of junior colleges.

Mr. Young reported that a mailing had been completed to a member of the VAS in each college with notification of the coming meeting. A mailing to 7,000 math and science teachers in the state is being

completed.

Mr. Young also submitted a draft copy of a brochure to Council, requesting comments on what should be included. He and the President reminded Council that a two-part brochure had been recommended; a directory which would be printed annually, and a promotional-historical document which would be printed in large volume and used until the supply was exhausted. In the discussion which followed, Dr. Harshbarger expressed concern over the 50th anniversary, and lack of preparations for it. The President read from the minutes of the Executive Committee of September 26, 1971, a recommendation that the list of past presidents and the recipients of VAS awards be published only in the proceedings issue of the Journal. Dr. Harshbarger moved that the recommendation of the Executive Committee be accepted; Flint seconded the motion but withdrew his second after additional discussion. It was not clear if another second was heard. The question was called and the motion carried by a voice vote with many abstentions. Dr. Bradley, acknowledging that he had voted for the motion, moved to reconsider the question (with second by Lowry) and the motion to reconsider carried. With no motion on the floor there was considerable discussion of the promotionalpublic relations value of a 50th anniversary document. Dr. Siegel moved that two existing items, the Directory and the Russell Rowlett folder, be continued, and the Executive Committee consider the question of a special commemorative publication, with the cooperation of the Publications Committee. The motion carried. Dr. Harshbarger requested that a cost-estimate of the 50th anniversary issue be made so that his committee could insure the funding.

The *Nomination Committee* reported its work complete, but withheld the names until the May meeting.

The Publications Committee had no report.

The *Research Committee* reported that 9 papers had been submitted for the Horsley award and that 4 research grants had been made.

The Science Talent Search reported that 41 students had been invited to the meeting. The 15 winners each will receive \$15.00 towards purchase of a handbook, and in cooperation with VJAS, each participant is given \$10.00 towards expenses.

The Trust Committee had no report.

A Flora Committee report was submitted.

There was no report from *Visiting Scientist Committee*.

Reports of ad hac Committees

Dr. Hughes reported for the *Museum of Science Committee*, noting that Dr. Rae Carpenter had been appointed a trustee. Dr. Hughes said the General Assembly had cut the proposed budget, and while there were funds for a director and operating expenses there were none for capital outlay. The office will be moved to new quarters on Governor Street in Richmond. He said the time table calls for completion of the Master Plan in 1973. Dr. Turner expressed his admiration to the Committee for the booklet prepared to promote the museum.

Dr. Hughes, as Chairman of the ad hoc Commistee on Conservation and Natural Resources, yielded the floor to the President who read parts of a letter requesting VAS endorsement of President Nixon's statement on wilderness. Dr. Turner had referred it to Dr. Hughes, who referred it to the Executive Committee. The Executive Committee recommended that the letter be circulated by mail to Council for

consideration at the May meeting.

The report of the ad hoc Committee on Academy Financial Structure had been circulated earlier to Council by mail. The President explained that he had sent a copy to the Chairman of the Constitution and By-Laws Committee and read portions of the response. The thrust of Mr. Midyette's remarks were that the present procedure of the VAS is somewhat at variance with the by-laws and correction is necessary, and that changes in the by-laws could begin at the May, 1972, meeting.

On motion by Dr. Carpenter, the Council voted to receive the report and to commend the committee for its diligence and requested the president to instruct the *ad hoc* committee to meet with the Committee on Constitution and By-Laws and to make a further report to Council as soon as possible.

President-elect Flint read the recommendations of his report with Council responding as follows:

Page 10, Item A. Recommendation that the Foley Smith fund be utilized for operating expenses of the Academy during any emergency situation of whatever nature, as determined by Council, when the principal can be effective in remedying or improving the situation. On motion by R. N. Gladding, recommendation was accepted.

Page 10, Item B. There was considerable and at times heated discussion of a proposal relating to the *Journal*. The salient points appear to be these:

In 1949 President Harshbarger received from the Council an agreement to issue a new *Virginia Journal of Science* providing a reserve fund of at least \$5,000 be solicited from the membership and from friends of the Academy to be held in reserve for the *Journal*. This fund was raised by the President and Dean Ivey Lewis and by a committee of the membership. A sum of \$5,000 was allotted to the *Journal* and separate books were kept for the *Journal*. When the Editorship shifted from Blacksburg to Richmond, the dual bookkeeping system was ended. The editor at present submits only estimated costs, and is not bound to any particular budget. The original \$5,000 reserve fund, created by advance payment of dues and other

devices, has long since been exhausted and the Journal presently shows a considerable deficit. The debate was ended when Council, at the suggestion of Dr. Bradley, referred Item B to the joint committee by authority of its carlier (Carpenter's) motion.

Item C, pages 11–12. The assets of the General Fund shall be reviewed by the Finance and Endowment and the Trust Committees. This review should focus on the investments presently under the cognizance of the General Fund, particularly the stocks and Savings Certificates, and this review should result in a proposal to Council for handling such investments. Accepted by Council on motion by Car-

Item D. With respect to the E. C. L. Miller Award, Council, on motion by Carpenter, approved the continuation of the present conditions.

Item E. Deferred pending the action of the Executive Committee on re-examination of our relationship with AAAS.

Item F. Referred by earlier (Carpenter's) motion

to joint committee.

Item G. Considerable discussion as to whether or not a change in the By-laws is required and useful. On motion by Dr. Siegel, Council approved the recommendation that each committee or section of the Academy which needs funds be requested to send their requests directly to the Executive Secretary-Treasurer before September 15 who will then collate them and consult with the Treasurer before presentation to the Finance and Endowment Committee.

Item H. On motion by Dr. Carpenter, Council approved a recommendation that the combined Trust Committee and Finance and Endowment Committee be charged with a decision as to the use or disposition of the Guy Horsley Fund of \$820.00. On motion by Dr. Harshbarger the Council commended the ad hoc committee for its fruitful study.

Reports of the Sections

Science Teachers: Leslie Watkins reported plans in 1972 for a luncheon rather than a breakfast mecting. A paper session may be incorporated on Wednesday night. Dr. Turner added that an open-house for VJAS members on Wednesday afternoon would free the teachers and allow them to meet together.

Microbiology: Date of 1976 meeting conflicts with

the national meetings.

Botany: Number system in recently printed membership directory did not reflect preferred section. Instructions from Dr. Flint: please be sure each section member expresses his preferred section at May meeting.

Future Meetings

The place of the 1976 meeting, scheduled on the agenda, was deferred to the May, 1972, meeting.

Old Business

The President reported that the current thinking on a business advisory committee is to form a group of past presidents to make known to the business and industrial community the desire of the Academy to cooperate in rendering public service.

Council expressed a favorable attitude towards cooperation with the State Department of Education

in reviewing possible textbooks.

New Business

Dr. Harshbarger moved that the Executive Committee prepare a program for the 50th anniversary meeting and to report at the May, 1972, meeting. Motion carried.

Dr. Turner announced that the Southeast Physical Society will make awards to some of our members at the assembly following the banquet.

News and Notes

VIRGINIA ACADEMY OF SCIENCE

1973 Meeting

50th Anniversary College of William and Mary Williamsburg, Va. May 1–4, 1973

1974 Meeting

Old Dominion University Virginia Wesleyan College Virginia State College Norfolk, Virginia April 30–May 4, 1974

1975 Meeting

Madison College Harrisonburg, Va. May 6–9, 1975

SCIENCE MUSEUM OF VIRGINIA

Appointment of Dr. D. Rae Carpenter as a Trustee, and substantial activity in the areas of legislative appropriations, establishment of a museum foundation, museum site and facility determinations, and future planning, have highlighted the Science Museum of Virginia's program for the past several months. Dr. Carpenter, immediate past president of the Virginia Academy of Science, and chairman of the Department of Physics at Virginia Military Institute, was named by Governor Holton to fill the unexpired term of Dr. Avery Catlin, who resigned. Dr. Carpenter's term on the nine-member board expires June 30, 1974. A native of Salem, he is chairman of the Research and Development Committec of the State Council of Higher Education. He joined the faculty at VMI in 1951, and became department head in 1969.

Museum operating expense appropriations from the State for the next biennium (1972–74) amounted to almost \$140,000, compared with \$66,500 for fiscal 1970–72. However, the Museum's request for \$119,000 for master planning, which was approved by the Governor, was deleted from the final budget bill. According to Dr. Roscoe D. Hughes, chairman of the Board of Trustees, "we are greatly encouraged by the increases in operating funds, and are confident that we will be able to find sufficient means to continue our planning program." The upcoming operating budget will permit, among other items, employment of a director, and possibly an additional staff member.

Dr. Hughes also thanked the many friends and supporters of the Museum throughout Virginia for helping to make possible "our accomplishments to date. This applies in particular to the strong support

and interest from the Academy membership.

In keeping with the Board's overall plan for fund raising, a Science Museum of Virginia Foundation

is being established to receive gifts and bequests for Museum use. This arm of the Museum operation will be activated in the immediate future.

Meanwhile the Board already has launched the first phase of its master planning program by authorizing preparation of a project report—designed to more closely define sites and initial facilities for the projected statewide museum system. For study purposes, specific sites are being considered in the Lynchburg, Norfolk, Portsmouth, Richmond, and Roanoke areas. Final recommendations as to number, type, and location of facilities will be determined by the Board after the master plan has been prepared. The Board also has designated, for study purposes, four types of initial facilities, located in the following areas: Lynchburg—industry and technology; Richmond—physical sciences, planetarium, and accommodations for the professional staff and planning unit; Roanoke—natural history (archaeology, paleontology, geology, etc.); and Tidewateroceanography, limnology (to include an aquarium). Each facility would be considered a major unit of the Museum system, and be designed to serve large segments of the population, while fitting into the cultural and educational plans of the community. These units will relate to the natural environment. and as now visualized, be located in a botanical setting.

To help determine the initial sites and facilities, Museum Trustees held a series of informal discussion sessions with Regional Advisory Committees in the areas under consideration. These groups were set up to provide a continuing mutual exchange of ideas and information, and their membership includes a diverse cross section of community leadership.

Technical Advisory Committees, such as the VAS Ad Hoc Committee and others, also have been established to provide more specialized knowledge in the various scientific disciplines covered by the Museum.

A special auction of mineral specimens, held under sponsorship of the Riehmond Gem and Mineral Society, has yielded a contribution of more than \$100 to the Science Museum of Virginia. Held during the annual Society-sponsored "Wonderful World of Rocks" show in Richmond in mid-May, the auction was the first of its kind during the event. The hundreds of items sold were given by Society members, dealers at the show, and other friends and supporters of the Museum.

Dr. Hughes called the gift "the kind of financial support and interest needed for the success of our Museum program."

DISTINGUISHED SERVICE AWARDS

Three members of the Association of Academies of Science, chosen by their Distinguished Service Award Committee, were honored at the annual banquet in December, 1971. Two were from the Vir-

ginia Academy of Science, Rodney C. Berry and Dr. E. L. Wisman. Wilmer W. Tanner, past president, was the third awardee and is from Utah.

These awards are presented each year to a member, or members, who have been active in their own academy, have shown considerable dedication, and have contributed to the continuing growth and prestige of the Association.

NEW DIRECTOR VJAS

In a recent letter to friends and supporters of the Virginia Junior Academy of Science, Dr. E. L. Wisman wrote.

"After a period of eight years, I am giving up the directorship of the VJAS. It seemed to be a time to make a change and to provide the opportunity for new ideas and leadership for the continual growth

of the VJAS program.

The new director, beginning June 1, will be Dr. Lee S. Anthony, Head of the Department of Physics, Roanoke College, Salem, Virginia. I assure you he is a most able and dedicated person and deserves all of the fine support that each of you has given to me these many years.

It has been most gratifying having all of you behind me. Without your support my effort would have been in vain, and I wanted you to know I appreciated

it."

NSF CHAUTAUQUA-TYPE SHORT COURSES, 1972-1973

The NSF Chautauqua-Type Short Courses for College Teachers, conducted by the American Association for the Advancement of Science with support from the National Science Foundation, are patterned after the "Chautauquas" of the early part of the century in which lecture, musical, and other programs of cultural interest moved in succession from community to community through a "circuit."

Twelve Field Centers have been established, organized into three "circuits" of four centers each. Ten courses will be offered in each of the twelve

Field Centers.

The typical pattern for each class is that the participants will meet at one of the centers for an initial two days of lectures, demonstrations, discussions, and preparation for individual work, study, research, or other activity to be carried out between that time and the second session—approximately three months. At the second two-day session, the participants will meet for discussion of the work that has been done and for a general "wrap-up." In the work assignments, consideration is given to the heavy academic loads of most college teachers.

The primary purpose of the program is to provide assistance to college teachers in the natural and social sciences, mathematics, and engineering in keeping their courses up-to-date, in introducing materials and models helpful in the development of new topics in their established courses, and in determining a basis

for the preparation of new courses.

Applications will be accepted from teachers of undergraduate students in the natural and social sciences, mathematics, and engineering from two- and four-year degree-granting institutions, including junior and community colleges and undergraduate faculties of universities. Any qualified teacher may apply at any Field Center. Participants will be expected to attend both sessions of the courses. Each class is limited to 25 participants. Application forms may be requested now. The Field Centers and coordinators are as follows:

EASTERN CIRCUIT

Hampshire College, Robert C. Birney, Vice President, Amherst, Massachusetts 01002.

The University of Maryland—College Park, Philip I. Connors, Department of Physics and Astronomy, College Park, Maryland 20742.

Syracuse University, Alfred T. Collette, Chairman, Center for Science Education, Syracuse, New York 13210.

Clark College, Alfred S. Spriggs, Head, Department of Chemistry, Atlanta, Georgia 30314.

CENTRAL CIRCUIT

Miami University, Charles M. Vaughn, Head, Department of Zoology and Physiology, Oxford, Ohio 45056.

The University of Missouri—Kansas City, Henry A. Mitchell, Associate Dean, College of Arts and Sciences, Kansas City, Missouri 64110.

The University of Wisconsin—Madison, Richard S. Hosman, College of Engineering, Madison, Wisconsin 53706.

Louisiana State University, Houston T. Karnes, Department of Mathematics, Baton Rouge, Louisiana 70803.

WESTERN CIRCUIT

Oregon Graduate Center for Study and Research, Lynn R. Sarles, Vice President for Administration and Planning, Beaverton, Oregon 97005.

Harvey Mudd College, Eldred Tubbs, Department of Physics, Claremont, California 91711.

Stanford University, Robert Bridgham, School of Education, Stanford, California 94305.

The University of Texas—Austin, Addison E. Lee, Director, Science Education Center, Austin, Texas 78712.

SUMMER SCIENCE INSTITUTE

The National Science Foundation has awarded a grant for the 1972 Summer Institute in Science and Mathematics for Secondary School Teachers at Randolph-Macon Woman's College, Lynchburg. This grant is under the direction of Dr. Helen L. Whidden, professor of chemistry and department chairman.

The summer institute is designated to strengthen the subject matter competence and to increase the classroom effectiveness of high school science and mathematics teachers. Participants specialize in biology, chemistry, mathematics or physics.

This is the 14th institute held at Randolph-Macon in the past 15 years, and is the third of a three-year sequential program which may lead to a Master of Science Teaching degree. Successful completion of

work for the degree includes twenty-four hours of course credit and a thesis for six credits.

The 1972 institute began June 26 and will continue through August 18.

NEW STUDY AT VISR

The Division of Aquatic Biology, Virginia Institute for Scientific Research has undertaken a joint pilot study with the National Environmental Protection Agency which will investigate the concentration and variability of pesticide residues in the James and Rappahannock estuaries. This will study the cycling and concentration of residues in various components of the estuarine ecosystem by analyzing sediments, plankton, oysters and fishes. The ultimate goal is to dctermine the effect of these chemicals on the important estuarine resources such as fish and oysters. It has been demonstrated that DDT has seriously reduced populations of fish-eating birds such as the bald eagle, and pesticides may be taking a toll of the fishes themselves. Pesticides must be kept well below lethal limits for several reasons. Pesticides may inhibit growth or reproduction of aquatic organisms as they do in birds. Sublethal doses combined with other stresses may be lethal. Pesticides tend to accumulate through the food chain from plankton to oysters and fishes. Residues may be reabsorbed from fat depots where they are stored in the body. Tainting and off-taste may be produced by pesticides. Pesticides and herbicides are useful but an integrated control strategy should be substituted for the mass onslaught and "saturation bombing" strategies. Clearly, pesticide studies must examine all components of the ecosystem.

VPI TURKEY RESEARCH

A study of certain environmental factors on the growth performance of turkeys is under way in Virginia Tech's department of poultry science.

The research, supported by a \$10,000 grant to the University from the Virginia Turkey Association, will explore the effects of intermittent vs. continuous light, light intensity and colored light on the growth performance, feed efficiency, mortality and market quality of turkeys at various periods in their lives. The influence of population density on these factors will also be studied.

A. T. Leighton Jr., professor of poultry science and director of the project, explained that previous work at Tech has indicated that different light environments have important effects of growth performance, feeding activity and behavior of turkeys.

Leighton and Davidson J. Gill, a graduate student in poultry science from Remlik, will compare the effects of light turned on and off every two hours with light turned on and off every 12 hours. In addition, they will study the effects of bright vs. dim white, blue and red lights. Birds will be raised with 0.8 square feet per bird vs. 1.6 square feet per bird through 14 weeks of age, after which time floor space gradually will be increased.

FAN MOUNTAIN TELESCOPE

The University of Virginia's new 40-inch reflector telescope, which was dedicated April 28 at the Fan

Mountain station of Leander McCormick Observatory, is designed to enable University astronomers to study some of the faintest objects in space and accurately record their positions and their motion. The new telescope will continue the work for which the observatory is famous—long-focus astrometry. It involves taking photographs on a large scale to measure the distance of stars from the sun.

The 40-inch telescope eventually will replace a 26-inch refractor telescope at Mount Jefferson, which is now more than 90 years old. Since its construction as the largest telescope of its kind in 1881, the 26-inch refractor has taken thousands of plates of the stars and the observatory's extensive collection of these photographs of the heavens has been used to measure the infinitestimal movement of stars over a period of years.

period of years.
"We discovered that repairing the old telescope, which is beginning to deteriorate, would cost as much as building a new one," said Dr. Laurence W. Fredrick, professor of astronomy and chairman of the department. "So we decided that to maintain our position in this specialized area, we would have to build a telescope with a new design."

The design was developed for the University by Dr. James Baker of Harvard University. It incorporates a large field of one degree with a very flat and stable optical system. This compromise between an astrograph, which classifies stars according to temperature, and a long-focus refracting telescope, keeps the cost and the size of the observatory dome within reason, according to Dr. Fredrick.

The new astrometric telescope is connected to a small control computer which is used to determine the exposure times for photographing stars, positioning the plates and tracking the telescope. The computer is able to move the telescope to any coordinate system and can direct it to track satellites and other objects not moving in the equatorial system. In addition there is a television system attached to the finder telescope which provides a picture of the view through the lens and which will eventually tell the computer what stars the telescope is looking at. It was constructed with funds from the National Science Foundation, the estate of the late Leander James McCormick and the University Alumni Fund.

The Fan Mountain observatory station, where the news telescope is located, is situated on a 215-acre tract near Covesville, 17 miles south of Charlottes-ville. University students and faculty members have been carrying out research there for nearly 10 years with a 32-inch reflector telescope and a 10-inch astrograph.

The prime contractor for the new telescope has been Davidson Optronics of West Covina, Calif., and the subcontractor for the large units and mechanical design was C. W. Jones, Engineering, of Commerce, Calif. The dome was built and installed by Observa Dome of Jackson, Miss., and the building was erected by the Long Construction Co. of Charlottesville.

The basic design of the automatic camera and the entire electronic system was handled by the department of astronomy's instrument shops under the direction of Hermann Bluemel and Robert Redick.

UVA MEDICAL DEAN

Dr. William R. Drucker, chairman of the department of surgery at the University of Toronto, Canada, and Surgeon-in-Chief of the Toronto General Hospital, has been named the new Dean of Medicine at the University of Virginia School of Medicine. He will assume his duties July 1, 1972.

Dr. Drucker became chairman of the department of surgery at the University of Toronto in 1966. He previously served 12 years on the faculty of the Case Western Reserve University School of Medicine.

Western Reserve University School of Medieine.

A graduate of Harvard College, Dr. Drucker received his M.D. degree from the Johns Hopkins University School of Medicine in 1946. After a year of internship at Johns Hopkins and military service with the Naval Medieal Research Institute at Bethesda, Md., he was assistant resident in medicine at the New Haven Hospital, New Haven, Conn. He was a research fellow in medicine at Case Western Reserve University in 1950 and later completed three years of residency in surgery at University Hospitals, Cleveland, Ohio. He is an authority on shock and trauma. His other research interests include the metabolic effects of surgery.

Dr. Drucker was selected as Markle Scholar in the Medical Sciences in 1958. Earlier, he was named a Scholar of the American College of Surgeons. He is currently on the editorial boards of the American Journal of Surgery and the Canadian Journal of Surgery and serves on the project committee of the General Medical Research Program of the National Institutes of Health. His memberships include the American College of Surgeons, where he serves on five committees; the American Association for Surgery of Trauma, of which he is treasurer; the American Surgical Association; the Central Society of Clinical Investigation; the Society of University Surgeons; the American Federation for Clinical Research; the American Association for the Advancement of Science, Phi Beta Kappa and numerous other organizations.

Dr. James T. Hamlin has served as aeting dean of the School of Medicine since March, when the post was left vacant by Dr. Kenneth R. Crispell's promotion from dean to vice president for health sciences following the retirement from administrative duties of former vice president Dr. Thomas Hunter.

NEW CHAIRMAN VCU PHARMACY DEPARTMENT

The Board of Visitors of Virginia Commonwealth University has announced the appointment of Dr. William H. Barr as Chairman of the Department of Pharmaey and Professor of Pharmaey effective July 1, 1972. Doetor Barr will sueeeed Doetor Milton L. Neuroth who has ehaired the department for over twenty years and has been a long time member of the Virginia Academy of Seienee.

Doetor Barr received his pharmacy education at the University of California in San Francisco and following a year of practice as a staff pharmacist in San Diego, entered graduate school at the University of California in San Francisco where he received his Ph.D. degree in 1966. Doetor Barr joined the staff of the State University of New York at Buffalo in 1966 where he remained until the present time. He has numerous publications in the general field of biopharmaceutics. He is currently a member of the Committee of Revision of the U. S. Pharmacopoeia and a member of the Subeommittee on Bioavailability. He is also a member of the American Hospital Formulary System Review Panel, a member of the American Pharmaceutical Association Steering Committee on the Drug Interaction Project, a member of the American Pharmaeeutical Association Handbook of Drug Interactions Scientific Review Panel, a member of the Academy of Pharmaeeutical Seienees Liaison Committee for Professional Affairs, a member of that Aeademy's Committee on Biological Performance of Drug Products and its Committee on Drug Product Equivalence. He serves on the Consultant Panel of the Poison Control Center at Buffalo Children's Hospital.

Doctor Barr is a member of Kappa Psi and Rho Chi. He is married and has three children.

JAMES W. ROBINSON, JR. SECONDARY SCHOOL

The largest seeondary sehool facility in Virginia was dedicated in a eeremony on March 12, 1972. Constructed on a 56.8 aere site in Fairfax County this modern educational eomplex cost about \$8.5 million and contains 491,219 square feet of space. The sehool opened in September, 1971, with about 3,600 students in grades 7-11. When grade 12 is added during the 1972-73 school year, it is expected to reach or exceed the capacity of 3,900. The facility was designed for a subschool organization. Chairman of the planning committee was Principal Samuel J. Coffey, then associate superintendent. Five subsehools will be operating 1971–1972 with a sixth to be added in 1972–1973. Each subschool will have its own principal, guidance personnel, administrators and staff of teachers to teach its 650-750 students. The building is completely air-conditioned. It has 174 teaching stations and 924 classes are taught daily. There are 78 standard elassrooms, 20 scienec laboratories and 6 media centers.

The school has been named for Sgt. James W. Robinson, Jr., who was awarded a posthumous Medal of Honor in 1967 for conspicuous gallantry and intrepidity in action while serving with the First Infantry Division in Vietnam. It was the first Medal of Honor given to a Virginia resident for the Vietnam conflict. The Department of the Army has prepared a special exhibit honoring Sgt. Robinson which is mounted in a display case in the main lobby of the school.

The principal speaker on the dedication program March 12, 1972, was Sgt. Robinson's father, James W. Robinson, Sr., now living in Miami, Florida. The Robinson family formerly resided in Annandale. The program included presentations by the Old Guard Fife and Drum Corps and the U. S. Army Drill Team.

ORLAND EMILE WHITE

Dr. Orland E. White, Professor Emeritus of Agricultural Biology and Director Emeritus of the Blandy Experimental Farm of the University of Virginia, died the morning of January 10, 1972, in a Charlottesville hospital, of complications following a broken-leg fall in his home a few days before. Survivors are a brother, Marion, in South Dakota, two daughters, Mrs. Dean Winchester, Baldwinsville, New York, and Mrs. James C. Quarles, Gainesville, Florida, and six grandchildren. His wife of more than fifty years, Loto Underwood, predeceased him some four years ago.

Dr. White was born April 25, 1885, in Sibley, Iowa, grew up in South Dakota, and received a B.S. and M.S. from the then State College of South Dakota, Brookings, (in '09 and '11, respectively). His graduate work in botany was done in the renowned Bussey Institution of Harvard University, from which he received an M.S. (1912) and the Sc.D. (1913). He joined the staff of the recently established Brooklyn Botanic Garden the same year. He was the "Eminent Botanist" of the Mulford Biological Exploration of the Amazon Valley, 1921–22, celebrated in the book, White Waters and Black, by

Gordon MacCreagh.

In 1927, Dr. White resigned his curatorship of plant breeding and economic plants to become the first director of the endowed Blandy Experimental Farm of the University of Virginia, near Boyce. His researches were principally in plant genetics, especially *Pisum*, but also tropical plants and winter hardiness. He has been widely recognized for his graduate training of the Blandy Fellows, several of whom have won the J. Shelton Horsley Research Award. After his retirement from this position he served as Visiting Professor at Sweet Briar College for two years. A memorial garden with some of his collected plants was dedicated there on May 7, 1962, by Dr. Elizabeth F. Sprague. A portion of the Blandy

Farm, some years ago, was set aside as the Orland E. White Memorial Arboretum. He was chairman of the Biology Section, Virginia Academy of Science, in 1931.

SIDNEY S. NEGUS HONORED

On May 25, 1972, an auditorium in Sanger Hall of the Medical College of Virginia, Health Sciences Division, Virginia Commonwealth University, was dedicated in memory of Dr. Sidney S. Negus, chairman of the Department of Biochemistry at the institution from 1927 to 1962. Dr. Negus died May 17, 1963. Dr. Negus served as Director of Public Information for the AAAS from 1938 to 1963, in the same capacity with the Federation of American Societies for Experimental Biology from 1960 to 1963, and for the International Congress of Nutrition held in Washington, 1960. The first of the annual Sidney S. Negus lectures was given at the dedication by Dr. William J. Darby, President and Scientific Director, The Nutrition Foundation, Inc. The title of his talk was "Food, Nutrition and Society," a topic which was in keeping with the interests and endeavors of Dr. Negus. In 1963 Dr. Negus, President of the Virginia Academy of Science, 1948–1949, received a service award from the National Association of Scicnce Writers for "his contribution over the past quarter of a century in bettering the public understanding of science."

PRELIMINARY NOTICE

The Southeastern Section of the Society for Experimental Biology and Medicine will meet on October 19 and 20, 1972, at the Medical College of Virginia, Health Sciences Division of Virginia Commonwealth University, Richmond. Symposia are planned on immunology and transplantation and on drug abuse. General sessions of submitted papers also will be scheduled.

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The recent flood in Richmond, Virginia destroyed most of the extra copies of **The Virginia Journal of Science**, prior to Volume 22, Number 4, 1971. Anyone having copies of older issues that they would like to donate to a needy cause, please send them to: **Dr. Charles E. O'Rear, Business Manager, Virginia Journal of Science**, 1 Nor:h 14th Street, Richmond, Virginia 23219

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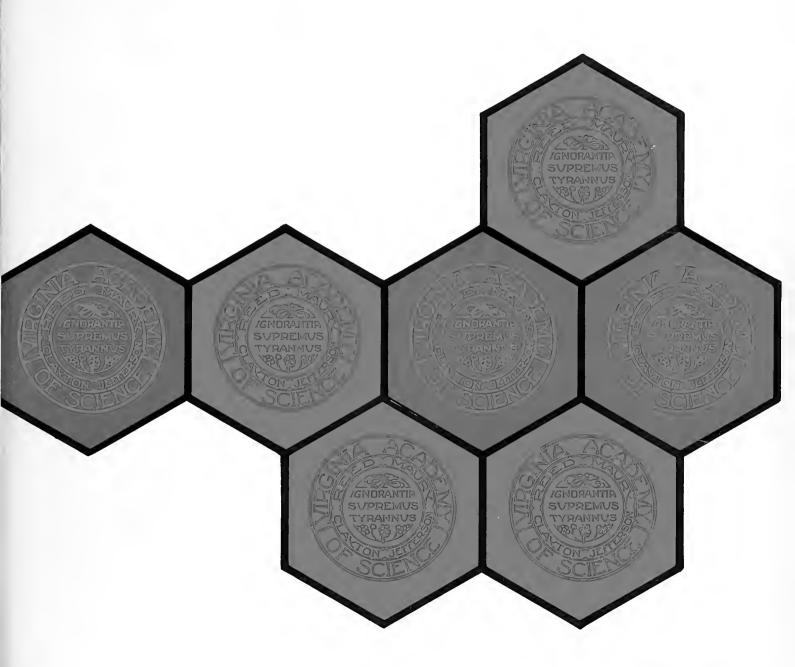
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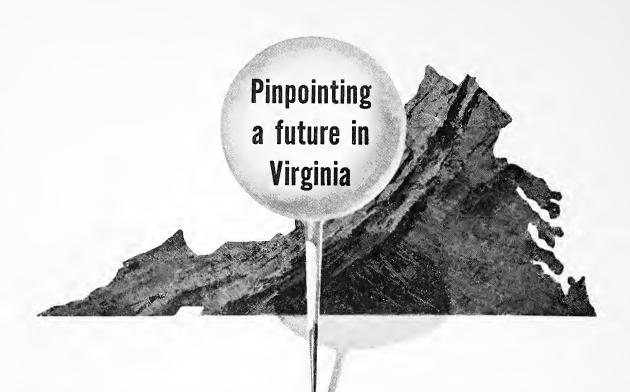
VIRGINIA JOURNAL OF SCIENCE

OFFICIAL PUBLICATION OF THE VIRGINIA ACADEMY OF SCIENCE



FALL 1972 VOL. 23, NO.3





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say our roots are planted deep in Commonwealth soil. Virginia is our "home state." Whatever we have contributed to its economy is returned many times in the close relationship we have with its people and its commerce.

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College of William and Mary

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George Mason College

Hollins College

Longwood College

Lynchburg College

Madison College

Mary Baldwin College

Mary Washington College

Mathematics and Science Center

Norfolk State College

Old Dominion University

Randolph-Macon College

Randolph-Macon Woman's College

Stratford College

Sweet Briar College

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University of Virginia

Virginia Commonwealth University

Virginia Military Institute

Virginia Polytechnic Institute

Virginia State College

Virginia Union University

Virginia Wesleyan College

Washington and Lee University

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Because of their interest in science and the economy of Virginia, the following industrial concerns have become Business Members of the Academy and have thus contributed greatly to its work and progress. Their support is gratefully acknowledged:

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The front cover is by Douglas C. Hensley.

VIRGINIA ACADEMY OF SCIENCE FIFTIETH ANNUAL MEETING, LEXINGTON MAY 3-5, 1972

SUMMARY OF COUNCIL MEETINGS AND ACADEMY CONFERENCE

Council met Wednesday, May 3, 1972, at 8:00 p.m. in Moody Hall, Virginia Military Institute, President Turner presiding, and again on Friday, May 5, 1972, at 7:30 a.m. in Crozet Hall, VMI, President Flint presiding. Minutes of the previous Council Meeting were corrected and a corrected version will be mailed to all Council Members.

On May 3 President Turner first called for reports

of Officers, Committees and Sections.

President-elect Flint offered the program as a re-

port of his duties.

Rae Carpenter, Co-chairman of the Local Arrangement Committee, reported that everything was progressing satisfactorily and that 583 had registered at the Junior VAS.

The following Section reports were submitted for presentation to the Academy Conference: Biology, Agriculture, Botany, Engineering, Statistics, and Space Science and Technology.

Lynn Abbott, Editor of the Journal, noted that the first issue of Vol. 23 was in the mail and that the

cover had been improved.

The report of the Nominating Committee was as follows: for President-elect Stanley Ragone; for Treasurer W. Allan Powell; for Secretary G. R. Brooks.

President Turner announced the award of the George B. Pegram medal by the Southeast Section of the American Physical Society to two members of the Academy.

WILDERNESS

President Turner reviewed the literature sent by Roscoe Hughes to Council members and the discussion at the recent meeting of the Executive Committee. He then opened the floor for discussion and/or action. A great deal of both followed.

Mr. Harshbarger moved that the President appoint a commission to investigate this affair and report to Council on Friday, May 5, 1972. There was no

second to this motion.

Mr. Midyette then moved the following, which was seconded by Mr. Flint: "The Virginia Academy of Science recognizes the importance of preserving our wilderness area and therefore urges its members to write the President of the United States requesting him to utilize the powers of his office to accelerate the programs of review of lands covered by the Wilderness Act of 1964." This motion was carried without dissent.

Mr. Bradley then moved that copies of the above motion be sent to President Nixon, to the Senators and Congressional Representatives of Virginia, and to Dr. Kindschi. Mr. Morrow seconded and the motion was passed.

Mr. Bradley then moved that the above two motions be submitted to the Academy Conference for endorsement. Again seconded by Mr. Morrow, the

motion was passed.

"RUSSELL ROWLETT" FOLDER

Mr. Bradley moved and Mr. Midyette seconded that Council accept the recommendation of the Executive Committee to authorize purchase of 5,000 copies of the "Russell Rowlett" folder to be used in recruiting new members. Motion was passed.

50TH ANNIVERSARY PUBLICATIONS

President-elect Flint will oversee plans for special publications commemorating the 50th Anniversary of the Academy.

DIRECTORY

Mr. Rowe moved acceptance of the recommendation of the Executive Committee to publish a list of past presidents and recipients of awards in the next issue of the Directory. Mr. Ragone seconded the motion and it was passed.

1976 MEETING SITE

Mr. Midyette moved acceptance of the recommendation of the Executive Committee to accept the invitation from George Mason University to serve as host for the annual meeting in 1976 and for the Executive Committee and appropriate officials from G.M.U. to set the dates for this meeting. Mr. Morrow faithfully provided a second and the motion was passed.

AD HOC COMMITTEE ON ACADEMY FINANCIAL STRUCTURE

President Turner reviewed action by Council (April 9, 1972 meeting) on the report by the Ad Hoc Committee on Academy Financial Structure. A copy of this report is attached to the official minutes.

Mr. Bradley moved that Recommendation B (page 10) be approved. The second was provided by reliable Mr. Morrow and the motion passed unanimously.

mously.

Mr. Morrow, in a change of position, moved that Council empower the President to facilitate the implementation of provisions included in Recommendation F. Mr. Clarke provided a second. After some discussion Mr. Clarke moved to table; Mr. Bradley provided a second. The vote on the motion to table was 7 for and 7 against; President Turner broke the tie by voting against. Again much discussion concerning problems with the Constitution and By-laws. Question was called and the motion passed 9 for and 7 against.

This being the last formal item of business Mr. Gladding wished to express his appreciation for serving on Council and thank members for their

work in aiding the Academy.

On May 5 President Flint called for reports and/or

comments from Committees and Sections.

Rae Carpenter, Co-chairman of the Local Arrangements Committee, reported that the exhibitors appeared to be satisfied with their arrangements, and that by having all section meetings in the same building registration was very good. He also noted that the division of labor between Washington and Lee (which handled the J.V.A.S.) and Virginia Military Institute (which handled the V.A.S.) worked very nicely.

It was suggested that at future meetings a notice in the program could emphasize the importance of the Academy Conference and that all members of the Academy should attend. Mr. Midyette suggested a resumé of prior Council actions could be given at the Conference meeting. Mr. Carpenter suggested that an agenda for the Conference meeting could be inserted in the program.

Mr. Clarke informed Council that the Sections of Astronomy, Mathematics and Physics will meet jointly with the Chesapeake Section of the American Association of Physics Teachers at the next annual

meeting.

President Flint will appoint a commission to study the relationship between the Academy and AAAS in light of the recent changes in the AAAS constitution. The President called upon members of Council for advice in planning special features to commemorate the 50th Anniversary. It was suggested that all living charter members and all living past presidents be recognized and that the program contain a short history of the Academy. Mr. Bruner will investigate the feasibility of overprinting Academy stationery with information about the 50th Anniversary and will report to the President.

Mr. Midyette moved that the No. 1 issue of Vol. 24 of the Virginia Journal of Science be designated as a commemorative issue. Mr. Morrow provided a

second and the motion passed.

Mr. Abbott moved to correct the minutes of Council Meeting on April 9, 1972. Motion was passed.

SUMMARY OF THE ACADEMY CONFERENCE

The Academy Conference convened in Mallory Hall, Virginia Military Institute, on Thursday, May 4, 1972. President Turner called the meeting to order and recognized Mr. Clarke.

Mr. Clarke moved that the Conference dispense with a reading of the minutes of the last Academy Conference. A second was provided and the motion passed.

The President then made the following comments: It had been a very instructive year; he had derived great satisfaction from working with members of the Academy, and was pleased with the current meeting. He represented the Academy at the inaugurations of the new presidents at the University of Richmond and Virginia Military Institute, and at the 75th Anniversary of Virginia Polytechnic Institute and State University. He also attended the annual meeting of the West Virginia Academy of Science.

President Turner then called for reports from

Officers and Sections.

President-elect Flint complimented the Local Arrangements Committee for their excellent work and thanked the Section secretaries for their prompt return of programs. He will appoint a commission to develop a special program for the 50th Anniversary at the College of William and Mary in 1973.

A report from the Treasurer is attached to the

official minutes.

The Secretary then read the reports of Committees and Sections. These reports are appended to the official minutes.

Mr. Boyd Harshbarger reviewed the report of the Financial and Endowment Committee pointing out that expected income would be approximately \$3,000 less than budgeted expenditures (mainly due to J.V.A.S. expenses). Mr. Harshbarger also voiced apprehension concerning future deficit spending.

Mr. Clarke advised the members present to con-

tinually search for advertising revenue.

LOCAL ARRANGEMENTS COMMITTEE

President Turner recognized Dr. Gilmer from Washington and Lee and Dr. Carpenter from Virginia Military Institute and thanked them for their work as Co-chairmen of the Local Arrangements Committee.

AAAS REPRESENTATIVE

President Turner recognized Dr. Raymond Taylor as the official representative of AAAS. Dr. Taylor expressed his pleasure at attending the meeting and briefly reported on changes in the constitution of AAAS, and how these changes might affect the Academy.

NEW BUSINESS

The Academy Conference endorsed the two motions passed by Council which dealt with the proposed executive order by President Nixon on Wilderness areas.

NOMINATING COMMITTEE

Dr. Carpenter, reporting for Dr. Siegel, provided the following slate of officers for 1972-73:

for President-elect—Mr. Stanley Ragone for Treasurer—Dr. W. Allan Powell for Secretary—Dr. Garnett Brooks

Dr. Carpenter moved that these nominations be accepted. A motion to close the nominations and accept the slate by acclamation was made, seconded, and passed.

REPORT OF THE LONG-RANGE PLANNING COMMITTEE

While the Long Range Planning Committee has been less active during 1971–72 than in the immediately preceding years, the Committee continues to be concerned over several issues facing the Academy.

First, the Committee views the two-year colleges to be a very significant development in our Commonwealth, and it urges all sections and committees of the Academy to be cognizant of this development so that the Academy might better serve the needs of the rapidly growing number of two-year college science faculty and students.

Second, the Long Range Planning Committee has discussed science textbook adoption procedures in the state, and it views the problem to be of sufficient importance to the education of future scientists to merit cooperation of the Virginia Academy of Science with the State Department of Education in consideration of the problem.

Third, the Long Range Planning Committee believes that the Virginia Academy of Science needs more systematic data collection. This information would enable trends to be more readily observed in such matters as Academy membership, income, expenses, etc.

Dale V. Ulrich, Chairman

REPORT OF THE CONSTITUTION AND BY-LAWS COMMITTEE

The Committee did not meet during the year. The Chairman served as parliamentarian for the May and November meetings of Council; but, was unable to attend the meeting of April 9, 1972. However, prior to the latter, the Chairman corresponded with the President relative to Constitutional and By-Law changes that might be necessary to implement the recommendations of the Ad Hoc Committee on Financial Structure.

The President was advised that merger of the Finance and Endowment Committee with the Trustee Committee would require amendments of both the Constitution and the By-Laws, and the By-Laws could not be amended in this regard until the Constitution is amended, and that the procedures for such could not be concluded until the May, 1973, Annual Conference and subsequent Council meeting.

The President was also advised that the Constitution provided that the duties of the committees shall be specified in the By-Laws and as further enumerated by the Council from time to time; and this being the case, Council could direct the committees to meet jointly and to further clarify the responsibility of each or both without amending either the Constitution or the By-Laws.

The Chairman also called the President's attention to the fact that the responsibility for investing funds belonged to the Trust Committee and not the Finance and Endowment Committee.

Having received no instructions to do so, the Constitution and By-Laws Committee has prepared no amendments to either the Constitution or By-Laws for consideration by Council or the Academy Conference during this (1972) Annual Meeting.

J. W. Midyette, Jr., Chairman

REPORT OF THE FLORA COMMITTEE

During 1971, the Flora Committee held two meetings, one in conjunction with the May meeting of the VAS at Blacksburg and the other at Clinch Valley College in Wise, Virginia on November 6, 1971. Reports of progress on the Virginia Flora Project were presented at each meeting. At Wise a field trip was sponsored to areas of former strip mining operations. Several papers relating to the Virginia flora were presented at the Section of Botany at the annual meeting of the VAS.

Members of the Flora Committee have continued active during 1971 on various aspects of the Virginia Flora Project. Work on specific families and genera and county collections have continued through the

Jeffersonia, a Newsletter of Virginia Botany, formerly called *The Newsletter*, published many current articles of ecological and taxonomic interest to field botanists of Virginia.

Peter Mazzeo of the U. S. National Arboretum completed his paper on the distribution of the four families of conifers of Virginia and has undertaken a similar study of the Betulaceae. Miles F. Johnson of Virginia Commonwealth University published a paper, "The Genus Liatris in Virginia" in Castanea and a second article in the Virginia Journal of Science on "The Genera Carphephorus, Mikania and Kuhnia (Eupatorieae-Asteraceae) in Virginia." Peter Mazzeo authored an article in Castanea entitled, "Taxus canadensis, Rediscovered in the Virginia Piedmont."

Dorothy C. Bliss, Chairman

REPORT OF THE AGRICULTURAL SCIENCES SECTION

The Agricultural Sciences Section will meet Thursday, May 4, 1972 from 8:00 a.m. to 5:00 in Room 249 Mallory Hall.

Twenty-four papers are scheduled for presentation. Topics range from the social environment of swine to the use of remote sensing in agriculture. Several papers are on subjects which are basic to maintaining the quality of the environment.

The varied subjects covered indicate that the Agricultural Section will have a most interesting program.

We invite each of you to attend when possible.

T. G. Copeland, Jr., Councilman

REPORT OF THE CHEMISTRY SECTION

No problems have occurred in the Chemistry Section requiring action of council. Everything has been planned for a successful meeting. Thirty-three papers will be presented on Thursday and Friday.

Randolph N. Gladding, Councilman

REPORT OF THE MICROBIOLOGY SECTION

The officers of the Microbiology Section are:

Chairman
Vice Chairman
Secretary
Councilman

Chairman
Mr. Louis D. Smith (VPI)
Harry P. Dalton (VCU)
William Steinberg (UVa)
S. Gaylen Bradley (VCU)

The Microbiology Section of the Virginia Academy of Science works closely with the Virginia Branch of the American Society for Microbiology. This effective liaison continues to be threatened by the proximity of the meeting dates of the VAS and the national ASM. This year the Microbiology Section program consists of only ten papers, largely because the national ASM meeting was last week. It should be noted that several papers by members of the Microbiology Section are being presented in other sections, apparently because some members believed that the Microbiology section would not sponsor a session at the 1972 VAS meeting in Lexington. The officers of the Microbiology Section have planned all year to meet this year (as usual) with VAS. The officers have initiated discussions about the possibility of not meeting with VAS next year (1973 in Williamsburg). It is the view of the present Councilman that the Microbiology Section will meet with VAS in 1973 but that the close connection with the Virginia Branch of the American Society for Microbiology may be weakened in the process.

There have been preliminary discussions with members of other sections about the desirability of joint sessions; for example, one dealing with algae, fungi, protozoa, bacteria and viruses or one concerned with water quality (pollution). A final decision on programming for 1973 will probably not be made until the autumn meeting of the officers of the

Microbiology Section.

The Microbiology Section believes that it has a contribution to make to VAS, and in turn, gains from the programs of VAS. We hope that our problems relating to the May meeting can be resolved satisfactorily.

S. G. Bradley, Councilman

REPORT OF THE GEOLOGY SECTION

Over 100 people, both professionals and earth science enthusiasts, attended the 3rd annual Virginia Field Conference of the Geology Section which was sponsored by the University of Virginia Department of Environmental Science in October 1971. This was a 2 day field examination of Triassic age rocks in Orange County and of Nelson County Hurricane Camille 1969 damage. For the 1972 annual Academy meeting 17 papers from both students and professionals will be presented. The invitational address will be "Energy Resource Problems in the Virginias"

by Dr. J. M. Dennison, Geology Department, University of North Carolina.

H. W. Webb, Jr., Councilman

REPORT OF THE ASTRONOMY, MATHEMATICS AND PHYSICS SECTION

The Spring 1972 program of the Astronomy, Mathematics and Physics Section consists of 28 papers, culminated by an invited paper "The Role of Abstraction in Quantum Mechanics," by Paul F. Zweifel.

The officers of the section are very pleased with the increased number of astronomy papers, and with the response to the invitations to a session on Physics Teaching, issued to all Universities, Colleges and Junior Colleges throughout the State.

A. M. Clarke, Councilman

REPORT OF THE BIOLOGY SECTION

The Biology Section of the Virginia Academy has not carried on any special activities during the year. However, individuals and groups have been active in research as evidenced by the large number of papers (67) submitted for presentation at this meeting. This unusual response is further justification for the newly created Botany Section which also has a full program of papers.

Warwick R. West, Jr., Councilman

REPORT OF THE BOTANY SECTION

The Botany Section has scheduled 31 papers from students and professional botanists in State institutions.

Leonard Morrow, Councilman

REPORT OF THE SPACE SCIENCE AND TECHNOLOGY SECTION

Section activities have centered solely upon preparation for the May 5, 1972 meeting of the Section at VMI. This year, twenty papers were contributed for presentation at the meeting and quality is high. A welcome change in the nature of the program is the increased participation by private industrial and research concerns. As a means of maintaining a broader interest in section activities, a congressman, T. N. Downing, and an astronaut, D. F. Eisele, were invited to appear as guest speakers, with Eisele speaking on NASA's upcoming Space Shuttle program and with Downing speaking on the future of space science as a national goal. As true in the past, the activities of this section continue to be the nucleus for formation of many useful lines of communication among groups of similar interests around the state.

Ralph A. Lowry, Councilman S. S. Fisher, Section Secretary

REPORT OF THE ENGINEERING SECTION

The Engineering Section officers, during the past year, met on two occasions in Richmond, Virginia,

primarily to discuss the 50th Annual Meeting arrangements. The theme selected for the meeting was "Recycling and Solid Waste Management," and a number of papers were received to be presented at the Engineering Section Meeting on May 4, 1972.

In addition to the discussion of program arrangements, the Engineering Section officers recognized the need for additional industrial participation on the Committee, since the press of business in one case and the transfer of another active Engineering Section member resulted in a depletion of industrial participation. The present officers of the Section are:

Chairman	Mr. F. C. McCormack
Vice Chairman	Mr. D. L. Michelsen
Secretary	Mr. E. G. Keshock
Editor	Mr. M. N. Bishara

The Engineering Section officers also individually reviewed two industry papers for a possible award at the May, 1972 meeting. The selection will be made on the basis of the recommendation of each reviewer as recorded by the Secretary.

Stanley Ragone, Councilman

SIDNEY S. NEGUS MEMORIAL LECTURE

Dr. Peter van de Kamp, Director of the Sproul Observatory, Swarthmore College, presented the annual Sidney S. Negus Memorial Lecture, "The Search for Extra-solar Planets in our Stellar Neighborhood" at the Academy Assembly, May 4, 1972.

J. SHELTON HORSLEY RESEARCH AWARD

Professor I. J. Good, Department of Statistics, VPI & SU and R. A. Gaskins, Department of Mathematics, Hampden-Sidney College received the 1972 J. Shelton Horsley Research Award for their paper "Global Nonparametric Estimation of Probability Densities" presented in the Statistics Section, Fiftieth Annual Meeting, Virginia Academy of Science, Lexington, Virginia, May 4, 1972.

FELLOWS OF THE VIRGINIA ACADEMY OF SCIENCE

The following members of the Virginia Academy of Science were elected Fellows by vote of the Council in session April 9, 1972 in accordance with the provision set forth in the Constitution, Article 4. Announcement was made at the Academy Assembly, Lexington, Virginia, May 4, 1972 and certificates were presented to those in attendance.

*	
Lynn D. Abbott, Jr.	Chairman, Department of Biochemistry Medical College of Virginia
Rodney C. Berry	Virginia Department of Agriculture and Commerce (Retired)

Lloyd C. Bird	Phipps and Bird, Inc.
Robert P. Carroll	Department of Biology Virginia Military Institute (Retired)
James W. Cole, Jr.	Professor of Chemistry University of Virginia
Walter S. Flory	Biology Department Wake Forest College
Mary E. Kapp	Chemistry Department (for- mer Chairman) Virginia Commonwealth Uni- versity
Paul B. Siegel	Professor of Poultry Science Virginia Polytechnic Institute and State University

REPORT OF THE FINANCE AND ENDOWMENT COMMITTEE

Budget as Prepared by the Finance Committee and Submitted to the Council

	Estimate for 1972
	101 1972
General Dues—Student Members	210
Dues—Regular Members	7000
Dues—Contributing Members	1450
Dues—Sustaining Members	1500
Dues—Business Members	3000
Dues—Delinquent Members	75
Advanced Payment Dues	
General Gifts, Grants & Bequests	3400
Junior Academy—Meetings	1000
AAAS Research Fund	
Dividends—Corporate Stocks	1600
Interest on Savings	
Annual Meeting—Exhibitor Fees	2500
Annual Meeting—Registration Fees	1780
Sale of Literature	
Va. Journal of Science—Income	5000
Other	
Total Receipts	28515
From Additional Gifts and/or any Surplus	
Generated	2590
Total	31105

Prospective Gifts

Philip Morris	1500
American Tobacco	500
Best Res. Paper	50
Berry	50
Vet. Med.	50
Reynolds	250
New	1000

Disbursement Budget Estimate

Disputsement Dauget Listing	•
	Gen'i Fund Est. 1972
Salary—Exec. Sec'y-Treas	1680
Clerical assistants	500
Office supplies and expenses	1000
General printing & section expenses	1600
Telephone	150
Postage	300
New typewriter	200
Annual meeting expenses & program	2000
Other meeting expense	300
Less Soc. Sec. & Income Taxes Withheld	
Social security taxes paid	120
Income taxes withheld paid	
Franchise tax	5

ECL Miller Award	50
Teacher Award	100
Science Talent Search	500
Va. Journal of Science Expense	11800*
Va. Jr. Acad. of Science Expense	9000
Visiting Scientists Program	400
Honorarium, speaker	200
Audit & tax service	500
Contingency fund—President	100
Contingency fund—Exec. Sec'y-Treas	500
Miscellaneous expense	100
AAAS Research Fund	
Other	
Total Disbursements	31105

^{*} Includes estimated earnings of \$5000.

Boyd Harshbarger, Chairman

Abstracts of Papers

Section of Agricultural Sciences

Fiftieth Annual Meeting of The Virginia Academy of Science May 3–5, 1972, Lexington, Virginia

ESTIMATING HERITABILITY OF HEREFORD COW WEIGHTS. L. L.
Benyshek and T. J. Marlowe. Dept. of Animal Science, VPI &
SU, Blacksburg, Va. 24061.
Cow weights were taken in 17 Virginia Hereford herds

during 1959 and 1970. There were a total of 1584 observations from which six subsets of data were formed for special analyses. Subsets were necessary because some observations did not contain complete data, such as offspring records or the sire of the cow. The complete model included year-herd, sire within year-herd, age of cow, condition score, year x age group, year x condition score and the regression of cow weight on days post partum. All analyses were performed by least-squares and maximum likelihood general purpose or SAS programs. All sources of variation were significant (P<.05) in one or more of the data sets. The least-squares constants indicated that cow weight increases up to about five years with little change thereafter. Cow weight increased linearly with condition score (score = 1,...,5), and also with days post partum at the rate of 0.020±0.014 to 0.045±0.010 kg per Heritability estimates, from three data sets, for unadjusted cow weight were 0.81+0.15, 0.15+0.07 and 0.22+0.06. Two estimates from data sets adjusted for age, condition, year x age group and days post partum were 0.84 ± 0.13 and 0.76 ± 0.15 . An indirect approach to obtaining a sire component of variance resulted in an estimate of 0.52+0.15. A direct approach to obtaining a sire component of variance using only the 1970 data and 483 observations representing 52 sire groups gave a heritability estimate of 0.88+0.19.

RELATIONSHIP OF CALVING DIFFICULTY IN BEEF CATTLE TO SUBSEQUENT PERFORMANCE OF COW AND CALF. K. P. Bovard, A. E. Jones*, and B. M. Priode*. Dept. of Animal Science, VPI & SU and USDA-ARS. Front Royal. Virginia 22630.

SU and USDA-ARS, Front Royal, Virginia 22630.

Births of 3491 calves from 1958 through 1969 were classified in each of 3 dichotomies: born alive or dead; with or without assistance; and, presentation vertex (normal) or breech. There were 7.6% stillborn; 4.3% pulled; and, 1.3% breech births. Data were also classified by breed: Angus, Hereford, or Shorthorn; by mating system: inbred or selection; by age of dam; and, by birth year. Calving difficulty was clearly related to dam's lactation status in preceding breeding season, χ^2 = 202 (P<< .01, d.f.= 15).

Among the 3491 calves born, the % born alive was 95.2 for 1980 calves from cows that were nursing the preceding breeding season; 89.2 for 727 calves from cows dry the preceding year; and 88.3 for 784 calves from primiparous cows. Preceding contrasts showed proportionately larger differences, and less favorable results among inbreds than among selection (non-inbred) calves; and, among males than females. ADG's to weaning were 1.61 for 80 calves pulled at birth, not statistically significantly less than that of 1.66 for 2891 calves whose dams were unassisted at birth.

INSECT RESPONSE TO PHYSICAL STIMULI - A PROGRESS REPORT.
U. F. Earp, J. V. Perumpral*, Agricultural Engineering Dept.
and J. L. Eaton*, Entomology Dept., Va. Polytechnic Inst.
and State Univ., Blacksburg, Va. 24061 and J. M. Stanley*,
Ag. Engr. Res. Div., ARS, USDA, Gainesville, Fla. 32601.

Traps using blacklight lamps as attractants catch more tobacco hornworm moths than traps using other lamps. Field observations have been confirmed by numerous laboratory studies. Behavioral studies show these moths respond better to light in or near the blacklight region than to light of longer wavelengths. Electromyographic studies indicate that maximal stimulus of the wing muscle occurs when the hornworm moth eye was subjected to radiation at about 360 nm.

Electrophysiological observations under field conditions resulted in electroretinographic response for hornworm moths when a 15-watt blacklight lamp was used as the stimulus at a distance in excess of 600 feet.

a distance in excess of 600 feet.
Sonic energy in the range of 100 H to 100 kHz produced no detectable response in face flies or houseflies.

Cabbage loopers were shown to respond under some conditions to certain sonic stimuli thus confirming the results of other investigators. They tend to respond well to stimuli in the range of 40 kHz if they are already in flight when the stimulus is applied. Otherwise little response can be anticipated. Study related to the full nature of their responses and ways of quantifying them are continuing.

AN ARENIC PLINTHIC PALEUDULT SOIL AND ITS INFLUENCE ON NUT-RIENT AND WATER MOVEMENT IN THE LOWER COASTAL PLAIN OF VA. W. J. Edmonds, W. F. Kitchel*, and B. L. Flippen*, Dept. of Agronomy, VPI & SU, Blacksburg, Va. 24061

This soil has thick sandy surface horizons greater than 50 cm thick and contains plinthite within 1.5 m depth. It was previously classified in the Norfolk series, and it has been extensively used for peanut production. An investigation of nutrient and water movement in this soil as a function of time was initiated in February, 1971.

Representing peanut fertilization practices, test plots received 2500 lbs. of dolomitic lime, 30 lbs. of N, 200 lbs. of P205, and 150 lbs. of K20 per acre in March. Samples were collected from each genetic soil horizon to a depth of 2 m for each test and check plot in early summer and fall.

Soil base saturation was low in the A horizon and highest in the upper Bt horizon indicating downward movement of added fertilizer through the thick sandy surface and accumulation in the lower clayey horizons during one growing season. Surface horizons exhibited seasonal variations in soil pH levels from 4.1 to 6.2.

Preliminary results demonstrate the importance of recognizing the thickness and texture of the surface horizon in the interpretation soil test results.

INFLUENCE OF SOILS ON CONTAMINATION OF A WATERSHED BY SEPTIC POLLUTANTS. $\underline{J.~H.~Elder,~Jr.}$, R. B. Reneau, Jr., and T. W. Simpson, Dept. of Agronomy, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The study area consisted of a 79.3 hectare watershed located between the Coastal Plain and the Piedmont Plateau in Spotsylvania Co., Va. Only 11.3 hectares (14%) of the watershed were Appling soils that are well suited to disposal of septic pollutants from domestic wastes. The remaining 68 hectares were composed of Colfax, Worsham, Senica, Louisburg, and Beltsville soils all of which are poorly suited for domestic wastes disposal.

Five septic tank systems located in Appling soils show no signs of failure; whereas, 27 systems in the remaining soils have effluent seeping to the surface. Fecal coliform counts \$\geq 2,400,000\$ MPN/100 ml were present where the effluent came directly to the surface. Subsequently, even at flood stages high counts of fecal coliform from failing septic systems and an elementary school discharging effluent from a sand filter are present in the drainage from this watershed. (Research supported by the Virginia Department of Health)

YIELDS OF S₁ LINES FROM ORIGINAL AND ADVANCED SYNTHETIC VARITIES OF MAIZE. <u>C. F. Genter</u>, Dept. of Agronomy, Va. Poly. Inst. & St. Univ., Blacksburg, Va. 24061.

Yields and inbreeding depressions were compared among approximately 200 $\rm S_1$ (first-generation selfed) lines from each of four maize populations, 'Iowa Stiff Stalk Synthetic', SSS, an advanced population, SSS(HT)C7, derived by seven cycles of recurrent based on test-cross yields, 'Virginia Corn Belt-Southern Synthetic', CBS, and an advanced population, CBS(S)C 4, derived by four cycles of recurrent selection for $\rm S_1$ progeny yield. The coefficient of inbreeding of each advanced population increased 5% or more per cycle.

Inbreeding depression decreased as the populations became inbred, averaging 39 and 28%, respectively, for S_1 lines from SSS and SSS(HT)C7, and 38 and 33%, respectively, for S_1 lines from CBS and CBS(S)C4.

SSS(HT)C7, with at least a 35% coefficient of inbreeding, yielded only slightly less than SSS. CBS(S)C4, with at least a 20% coefficient of inbreeding, yielded 19% more than CBS. Inbreeding need not be detrimental to yield.

CBS. Inbreeding need not be detrimental to yield. The maximum \mathbf{S}_1 yield from each population approximated that of the parental population. \mathbf{S}_1 lines from SSS(HT)C7 averaged 9% higher than those from SSS, whereas \mathbf{S}_1 lines from CBS(S)C4 averaged 27% higher than those from CBS. Two \mathbf{S}_1 lines from CBS(S)C4 were comparable in yield to that of an adapted double cross hybrid check. Thus, one very effective means of increasing inbred line yields is to first increase the yields of inbred source populations.

RELATIVE NEMATODE POPULATIONS IN SOIL FOLLOWING TEN YEARS OF CONTINUOUS CORN OR A CORN-PEARUT ROTATION. D. L. Hallock, L. I. Miller, and B. J. Gray*. Tidewater Research Station, Va. Polytechnic Inst. and State Univ., Holland, Va. 23391.

An experiment was initiated on Woodstown loamy fine sand at Holland, Va. in 1962 to compare the productivity of corn grown continuously versus corn in rotation with peanuts. Ten years after the experiment was initiated, soil samples were collected from the surface soil along growing crop rows and assayed for plant parasitic nematodes. Very low populations and sporatic distribution of stubby root, lance, and spiral nematodes occurred. Populations of the stunt nematode were highest in continuous corn plots, but they were higher in corn than in peanut plots of the rotation system. The low population in peanut plots indicates that the stunt nematode does not reproduce on peanuts. Populations of the northern rootknot nematode (NRK) were much higher in peanut than in corn plots. Since corn is not a known host of the NRK, either a new race of NRK developed or a weed host maintained low populations of NRK in corn plots. Populations of the ring nematode were highest in the peanut plots and lowest in the continuous corn plots.

It is believed that the stunt and other plant parasitic nematodes did not limit corn production in the experiment, but that some injury to peanuts was incurred by the NRK and ring nematodes.

INTERRELATIONSHIP OF DIETARY COPPER AND IRON IN GROWING PIGS J. D. Hedges* and E. T. Kornegay, VPI & SU, Dept. of Animal Science, Blacksburg, VA 24061.

Three trials were conducted involving 132 pigs to measure the effect of various levels of Cu and Fe on growth, hematology and tissue stores. Rations containing three levels of Cu, 7, 25 and 250 ppm and two levels of Fe, 101 and 264 (312 in trial 3) ppm, were limit-fed in trials 1 and 2 and full-fed in trial 3. Growth was increased when the diets containing the highest level of Cu were full-fed regardless of the Fe level. Hemoglobin values were depressed by feeding 250 ppm Cu when the diet contained 101 ppm Fe. Serum Cu concentrations were increased at 2-wks. in trial 1 and 2 and at 6wks. in trial 3 when pigs were fed diets containing the highest Cu levels. Serum Fe concentrations were depressed at the highest dietary Cu level and increased at the higher Fe level. The highest dietary Cu level increased liver Cu stores and decreased liver Fe stores. High dietary Fe levels increased liver Fe stores. The concentration of Cu in the kidney was increased by feeding diets containing 250 ppm Cu. Fe content of the kidney was increased when diets contained 25 ppm Cu, but not when diets contained 7 or 250 ppm. The Cu content of the spleen was not changed by the dietary Cu level. Fe content of the spleen was increased when diets contained 25 ppm Cu and decreased when diets contained 250 ppm Cu. It appears that 7 ppm of Cu is adequate for normal hematology and growth, and that 250 ppm Cu will improve growth rate.

ARTIFICIAL REARING OF BABY PIGS. E. T. Kornegay, Dept. of Animal Science, VPI & SU, Blacksburg, VA 24061.

Presently about 25% of the pigs farrowed are lost before weaning with most losses occurring during the first 3 days. A series of trials are in progress to develop the management and nutrition necessary to artificially rear, using newly developed automated equipment, baby pigs taken from the sow soon after birth. In the first two trials, 48 baby pigs were weaned at 12, 48, 96 and 144 hr. and placed in individual cages in a temperature controlled room. In both trials, pigs were hand-fed 5 times each day with fortified whole cow's milk. Fortification per kilogram was: 5mg Cu, 50mg Fe, 50mg Zn, 5000 IU Vit. A, 1000 IU Vit. D, 5 IU Vit. E, and 70gm dried skimmed milk. After about 14 days, a commercial sow milk replacer was automatically fed every 90 min. At 28 days, pigs weaned at 12 hr. were slightly lighter than pigs weaned at a later time (5.40 vs 5.73 kg) and artificially reared pigs weighed the same as litter-mate pigs left on the sow. Death losses were: trial 1 - one pig weaned at 96 hr.; trial 2 - three pigs weaned at 12 hr. and 1 pig weaned at 48 hr. Pigs which died in trial 2 had received little or no colostrum prior to weaning. Also, pigs in trial 1 were 177 gm heavier at birth than pigs in trial 2 (1296 vs 1119 gm). The greatest problem incurred in these trials was that of controlling diarrhea. Oral treatment with kaopectate and milk of bismuth was partially effective. The greatest amount of diarrhea occurred in pigs weaned at 12 and 48 hr.

CROSSBREEDING FOR BEEF PRODUCTION. <u>T. J. Marlowe</u>, R. C. Carter and A. L. Grizzard*. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061 and Va. Dept. of Welfare and Inst., Richmond, Va. 23220

Extensive crossbreeding research was initiated in 1968 between the Animal Science Dept. of Virginia Polytechnic Inst. and State Univ. and the Va. Dept. of Welfare and Inst. to (1) evaluate several sire breeds (Phase I), (2) evaluate several dam breeds and crosses (Phase II), and (3) determine best combination of breeds and mating schemes for maximizing beef production. Approximately 750 Hereford and 125 Angus cows in 5 prison farm herds are mated to Angus, Brown Swiss, Charolais, Hereford, Holstein, P. Hereford, Shorthorn, and Simmental bulls annually in Phase I. Crossbred and straightbred heifers are saved for comparison in Phase II. Cow breed groups will vary in size from 25 to 50 and each group bred to produce a minimum of 50 offspring. To date, 2 calf crops have been weaned at 3 locations and 1 calf crop at 1 location. Calf crops will be weaned at all locations in 1972. With performance records on 668 calves and on 485 yearlings, significant herd and sire differences are apparent. In general, sires mated to Hereford cows rank in descending order of Simmental, Charolais, Holstein, Shorthorn, Angus, and Hereford, based on 205 and 365 day calf weights. When bred to Angus cows the rank was Charolais, Holstein, and Angus. Phase II females are calving for the first time in two locations and being bred for 1973 calving at four locations.

A COMPARISON OF ANGUS, CHAROLAIS, AND HOLSTEIN BULLS ON ANGUS COWS. T. J. Marlowe, R. C. Carter and E. M. Grizzard*. Dept. of Animal Science, VPI & SU, Blacksburg, Va. 24061 and Va. Dept. of Welfare and Inst., Capron, Va. 23829.

Each year 90 Angus cows were allotted at random within age groups to two bulls each of Angus (A), Charolais (C), and Holstein (H) breeds for a 75-day breeding season. The offspring were weighed at approx. 7, 12 and 18 months of age. All groups were treated alike within sexes. Calving percentages for two breeding seasons were 75, 78 and 80 for A, CA and HA, respectively. Birth weights were 27.5, 34.2 and 33.8 kg. Calf weights were lower in '71 than in '70 by 23 kg at 205 days and 2 kg at 365 days. CA steer calves weighed 36 kg heavier than A and 27 kg heavier than HA calves at 205 days. Heifer differences were 29 and 18 kg. Similar differences at 365 days were 53 and 23 kg for steers and 49 and 27 kg for heifers. CA calves graded slightly higher than AA and 2 grade points higher than HA calves at both weigh periods. AA calves were in best condition and HA calves were in poorest condition. All groups combined, steer calves were 2.7 kg heavier at birth, 9 kg at 205 days and 30 kg at 365 days than heifers, with no significant difference in grade or condition. Carcass data on 29 steers showed CA steers superior in carcass WDA, ribeye area, yield grade and percent lean cuts. HA steers were intermediate in nearly all traits measured. AA steers were superior in marbling and carcass grade but were much fatter, more wasty, and had smaller ribeyes per hundred weight of carcass.

THE EFFECT OF GROUP VS. INDIVIDUAL CONFINEMENT ON THE REPRODUCTIVE AND BEHAVIORAL PATTERNS IN YOUNG BOARS IN PASTURE-LOTS AND ON CONCRETE. T. N. Meacham* and Billy H. Wells*. Dept. of Animal Science, V.P.I. & S.U., Blacksburg, Virginia 24061

The effect of group vs. individual confinement in pasture-lots and on concrete was compared using 16 purebred and crossbred boars with an average weight of 54 kg and average age of 120 days. Libido, age at puberty, semen characteristics and occurrence of aberrant sexual behavior were studied in a 185 day trial.

Aberrant sexual behavior was greater (P<.001) in the allmale group on concrete. The percent abnormal sperm was the only semen characteristic which differed significantly (P<.05) between individuals within sub-treatments in pasture-lots. Due to "concrete lameness", which prevented successful collection of semen, no semen data were obtained from the boars on concrete.

Greater libido, earlier puberty and more aggressive behavior were exhibited by the individual boars in pasturelots followed by the all-male group on concrete, individual boars on concrete and the all-male group in pasture-lot.

RESISTANCE OF PLANT INTRODUCTIONS OF ARACHIS HYPOGAEA TO MELOIDOGYNE HAPLA, MELOIDOGYNE ARENARIA, AND BELONALAIMUS LONGICAUDATUS. L. I. Miller. Dept. of Plant Path. & Physiol., V.P.I. & S.U., Blacksburg, Va. 24061.

The resistance of 2000 peanut introductions (series P.I. 109834 - P.I. 274267) was evaluated (Ross-Brim double row method using Va. 46-2 Bunch variety as the susceptible check) on: one farm near Surry, Virginia infested with the peanut root-knot nematode (Meloidogyne arenaria; one farm near Cypress Chappel, Virginia and one farm near Holland, Virginia infested with the northern root-knot nematode (M.hapla); and one farm near Suffolk, Virginia infested with the sting nematode (Belonolaimus longicaudatus). None of the lines were resistant to the development of the peanut root-knot and sting nematodes and root abnormalities caused by these nematodes. On the farm near Cypress Chappel, the lines P.I. 149636 (Bunch growth habit with Valencia type fruit and a red testa) and P.I. 158838 (Runner growth habit with Virginia type fruit and pink testa) were highly resistant to the northern root-knot nematode. On the farm near Holland, these two lines and all others tested were not resistant to the northern rootknot nematode. These findings suggest that races of the northern root-knot nematode occur in the peanut-producing area of Virginia.

MULTISPECTRAL INTERPRETATION VIA REMOTE SENSING OF SOILS AND CROPS IN SELECTED COASTAL PLAIN SOILS OF VIRGINIA. M. E. Newhouse and D. E. Pettry, Department of Agronomy, VPI & SU Elacksburg, Virginia 24061

During the 1971 growing season 14 photographic missions were flown of the Va. Truck and Ornamentals Farm at Painter, Va. Twelve of these flights utilized infrared and conventional films only, while two flights utilized thermal scanners. These data were evaluated for both helicopter and fixed winged aircrafts between altitudes of 500 to 10,000 feet.

Ground truth data were collected for each mission. These consisted of several plant, soil, and climatic variables. This data was later used to classify each field for analysis.

Photographic results have been analyzed by two methods. First, each field with a different treatment was color coded using the Munsell color system. Second, an isodensitometer was used to identify areas on the positive transparencies with similar densities. Several flights could not be evaluated by the isodensitometer because of the vignetti effect. This has since been corrected, but still a slight color shift from one photograph to another poses a problem.

Results of one scanner flight have been very encouraging. Computer analysis of the scanner tapes indicate that plant species, plant conditions, and soil conditions may be accurately classified if appropriate ground truth is available. (Aided by NASA grant NAS6-1863).

SEPAL REMOVAL ON DELICIOUS AND YORK IMPERIAL APPLE AS ASSOCIATED WITH FRUIT SET. G. D. Oberle. Dept. of Horticulture, Va. Poly. Inst. & St. Univ. Blacksburg, Va. 24061

Blossoms of most varieties of apple can be emasculated for controlled pollinations by removal of the distal portion of the calyx along with petals and stamens. If carefully done with scalpel, forceps or use of finger and thumb nails adequate sets of fruit can be expected after subsequent pollination. Flowers of Delicious and its numerous sports when so emasculated fail to set fruits. York Imperial blossoms respond similarly under similar treatment. Flowers of both varieties set reasonable proportions of fruits if emasculation is accomplished by removal of petals and stamens with forceps leaving the calyx intact. Removal of sepals from blossoms of Delicious at, or after, time of pollination did not effect the set of fruit. Removal of from one to five sepals per blossom at the time of emasculation reduced fruit set in proportion to the number of sepals removed. On York Imperial removal of increasing numbers of sepals per blossom was associated with a tendency for decreasing set of fruit.

REMOTE SENSING IN VIRGINIA AGRICULTURE. D. E. Pettry and M. E. Newhouse, Department of Agronomy, VPI & SU, Blacksburg, Va. 24061

A cooperative research project of remote sensing in agriculture was initiated in July, 1970, by the Agronomy Dept. of Virginia Tech, the National Aeronautics and Space Administration, Wallops Island, Va., and the Va. Truck and Ornamentals Research Station, Painter, Va. Initial objectives and methodology were designed to develop and evaluate multispectral sensing techniques for the detection of plant species and associated disease, soil variation, and cultural practices. The primary research site at the Painter Experiment Station is comprised of a 100 acre farm arranged in rectangular fields.

Infrared photography and multispectral sensing techniques are employed from aerial platforms of helicopters and fixed winged aircraft at various altitudes. An environmental monitoring station has been installed at the research site to continuously monitor solar radiation as well as air, soil, and plant temperatures, relative humidity, and wind speed and direction. Preliminary results indicate that an increase of 100% in reflection between a wet and dry soil may commonly occur in bare siliceous soils. Evaluations indicate that bare soils and areas containing vegetable crop species with small leaf area appear quite similar on color infrared photographs taken at altitudes of 500 feet and greater. (Aided by NASA Grant NAS6-1863).

THE MOVEMENT OF SEPTIC TANK EFFLUENT IN SELECTED COASTAL PLAIN SOILS OF VIRGINIA. R. B. Reneau, Jr. and D. E. Pettry, Department of Agronomy, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061.

The movement of total and fecal coliform, surfactants,

The movement of total and fecal coliform, surfactants, phosphorus (P) and nitrate (NO3) from septic tank effluent through natural soil systems were monitored utilizing series of piezometers to collect samples at selected distances and depths. The soils studied were considered to be marginally suited for the disposal of domestic wastes because of fluctuating seasonal water tables and/or restricting layers. In older systems total and fecal coliform bacteria were observed to move both horizontally and vertically. Coliform counts exceeding 46,000 (MPN)/100 ml were present at depths of 1.75 meters at distances of 6 meters from the drainfield. Surfactants and P traveled less than 1 meter distances through these natural soil systems. Nitrate accumulations were encountered approximately 2.5 meters from the drainfield indicating increased nitrification. Decreases in NO3 concentrations were noted at distances of 6.0 meters due to denitrification and/or dilution. (Research supported by the Virginia Department of Health).

EFFECT OF LIME ON NASON SOIL TWENTY YEARS AFTER APPLICATION.
S. Sampath*, C. I. Rich, and G. D. Jones. Agronomy Dept.,
VPI & SU, Blacksburg, Va. 24061
The long term effects of liming under field conditions

The long term effects of liming under field conditions on soil acidity and other soil reactions of Nason silt loam were studied. The soil was limed in 1951 with dolomitic limestone at the rates of 0, 1, 2, 4, 8, and 16 tons per acre in a randomized block design. Composite soil samples were collected in 1971, 20 years after the application, from surface (0-6 inches) and subsurface (6-12 inches) layers.

After 20 years the effects of lime in amounts up to two tons per acre were scarcely detectable in both soil layers. However, the application of limestone at 4, 8, and 16 tons per acre considerably increased the pH and exchangeable Ca and Mg content, and significantly decreased the exchangeable Al content of both 0-6 inch and 6-12 inch layers. A significant decrease in the pH-dependent acidity of both the soil layers was observed after the application of eight tons of lime. In the surface layer, increasing the application from 8 to 16 tons per acre resulted in the neutralization of a greater proportion of pH-dependent acidity, whereas in the subsurface layer there was no further decrease after the application of eight tons of lime.

Liming had no apparent effect on the X-ray diffraction patterns of hydroxy-Al interlayered vermiculite, an important clay mineral in the soil.

CARBOFURAN (FURADAN) FOR THE CONTROL OF INSECTS AFFECTING CORN IN VIRGINIA. J. E. Roberts, Sr. * Dept. of Entomology, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Ten per cent granular carbofuran, a systemic insecticide, is currently labeled for the control of rootworms and for aid in the control of first generation European corn borer. It is recommended that this chemical be applied in a narrow band in front of the planter press wheel at planting time at the rate of one pound of active ingredient per acre.

Observations made in 1971 strongly indicate that this same type of application will result in the control of the armyworm, a serious foliar pest of no-till corn in Virginia.

VALUE OF THRIPS CONTROL ON PEANUTS IN VIRGINIA. J. C. Smith. Res. Div., Va. Polytechnic Inst. and State Univ., Tidewater Res. Sta., Holland, Va. 23391.

Control of the tobacco thrips, <u>Frankliniella fusca</u> (Hinds), on Virginia-type peanuts has failed to increase yields in experiments conducted from 1965 through 1971. Yield and value/acre data of a 1971 experiment showed increased values over untreated controls from treatments that included a nematicide. Plots receiving systemic control of thrips without accompanying nematicidal effects had yields that averaged 271 lb/acre less than untreated controls and had a corresponding value decrease of \$33.00/acre. Plots receiving thrips control from a foliar spray were about equal to untreated control plots. The value of the cosmetic effect of thrips control has not been determined, but should receive low priority in this era of consciousness concerning pollution and the environment.

HYDROLYZED HOG HAIR MEAL AS A PROTEIN SOURCE FOR SWINE. H. R. Thomas and E. T. Kornegay, Dept. of Animal Science, Va. Polytechnic Inst. & State Univ., Holland and Blacksburg, Va.

Four trials using 285 crossbred pigs were conducted to evaluate hydrolyzed hog hair (HHH) meal as a protein source for swine. Using diets with zero to 8% added HHH meal, it was found that 2-3% HHH meal could be substituted for soybean meal without depressing gain and increasing feed/gain if the diets were formulated on a digestible protein basis. Feed intake was not severely depressed until more than 6% HHH meal was added. Carcass characteristics were not affected by the substitution of HHH meal in the diet on an equal digestible protein basis. The failure to get a response to higher levels of HHH meal suggests that less than 70% of the protein is utilized by the pig, that amino acid deficiencies and inbalances were occurring or that the amino acids were not as available as in soybean meal and corn.

<u>UPTAKE OF THREE HERBICIDES BY FOUR SPECIES OF ALGAE.</u> J. P. <u>Valentine</u> and S. W. Bingham, Dept. of Plant Pathology and Physiology, VPI & SU, Blacksburg, Virginia 24061.

Four algae were studied for their ability to remove selected herbicides from water. The algae used in these studies were <u>Chlorella pyrenoidosa</u> Chick, <u>Scenedesmus quadricauda</u> (Turp) Breb, <u>Chlamydomonas reinhardtii</u> Dangeard and <u>Euglena gracilis</u> Chod. and Prov. var. urphoria. The herbicides used were 2,4-Dichlorophenoxyacetic acid (2,4-D), 3-amino-s-triazole (amitrole), and 2-chloro-4-(ethylamino) -6-(isopropylamino)-s-triazine (atrazine). All herbicides were ¹⁴C labeled.

Cells used in the removal studies were taken from actively growing batch cultures which were maintained in a growth chamber at 20°C under continuous light. The cells were concentrated by centrifugation and resuspended in pond water containing the herbicide buffered at various pH values. The cultures were sampled at various intervals to determine the amount of label remaining in solution.

Scenedesmus was particularly effective in removing the pesticides from water. Maximum uptake for 2,4-D was exhibited at low pH whereas uptake of amitrole and atrazine was most pronounced at neutral or somewhat alkaline pH values. The other algae were not nearly as effective in removing the herbicides from water over a pH range of 4.7 to 8.3.

PROFESSIONAL FIELD DAY: A STIMULUS TO UNDERGRADUATE RESEARCH PROGRAMS IN AGRICULTURAL SCIENCE. R. T. Wilfong and J. H. Elder. Dept. of Biology, Mary Washington Col., Fredericks-burg, Va., and VPI & SU, Blacksburg, Va. An undergraduate Plant Ecology course was initiated at

Mary Washington College of the University of Virginia in the fall of 1971. In an effort to give students an opportunity to conduct a professional program of their own and to stimulate interest in professional activities, a Soil Field Day was held as an integral part of the course. Since the course was strongly research oriented, it was felt that such participation would give students an insight into graduate and professional field days, which are generally related to research activities. Department chairmen from other colleges, high school representatives, as well as soil and turf scientists were invited for the day-long sessions. The morning session was devoted to papers and discussions on soil and soil ecology by members of the VPI & SU Agronomy staff. The afternoon session was conducted in the field. Six soil types were observed at sites in the Fredericksburg area. The soil types were representative of those studied in the classroom prior to the event. Students were involved in both planning and carrying out the program. Such involvement not only gave the students training in implementing such a program, but also gave them a better understanding of how their

own research would be presented at professional meetings.

Section of Astronomy, Mathematics, and Physics

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

T-TAURI STARS-NEWLY FORMED OBJECTS IN OUR GALAXY.

T-TAURI STARS-NEWLY FURLED OBJECTS IN OUR GALAXY.

J. H. Akyüz*. Dept. of Astronomy, Univ. of Va.,
Charlottesville, Va. 22903

T-Tauri stars are a group of young variables
with characteristics: (1) Rapid, irregular
light variations (2) F to M spectral types, with
a spectrum of strong emission lines of hydrogen
and CaII, and absorption lines of LiI (3) Low
Luminosity (4) Association with Sark and bright and call, and absorption lines of Lil (3) low luminosity (4) Association with dark and bright nebulosities. They are within one kiloparsec of distance from the sun, showing high distribution toward the center and the anticenter of the Galaxy with \(\times\)20° inclination to the galactic plane. These stars possess circumstellar gas and dust envelopes of \(\times\)10 A.U. in diameter, which give rise to ultraviolet and infrared crosses.

give rise to ultraviolet and infrared excesses.

The violet displaced absorption components of emission lines indicate mass loss with a velocity of ~ 150 km/sec and a rate of $\sim 3.8 \times 10^{6}$ mo/year, on the average.

The absorption line widths are extraordinarily wide, due to stellar rotation and/or vertical turbulence in the atmospheres of these stars.

T-Tauri stars are believed to be highly convective, pre-main sequence, contracting protostarsnewly formed objects in our Galaxy. They have have absolute brightness of \sim +5 magnitudes and are about 106 years old.

OPTICAL ABERRATIONS OF THE McCORMICK 26-INCH OPTICAL ABERRATIONS OF THE MCCORMICK 20-INCH
REFRACTOR. J. B. Ashcraft* and A. C. Miller, Dept.
of Physics, Va. Mil. Inst., Lexington, Va. 24450
and P. A. Ianna, Dept. of Astronomy, U. of Va.,
Charlottesville, VA 22901
Recently a new objective grating, designed by
one of us (Ianna), was built for the McCormick
26-inch mefractor. It provides the megnitudes of

26-inch refractor. It provides two magnitudes of reduction between the central and first order images. It was used to study the magnitude and coma effects of the 26-inch. The results agree It provides two magnitudes of with those obtained earlier by Jefferys, W. H., 1962 (Astrom. J., Vol. 67, 533) and Eichhorn, H. K., 1970 et al. (Mem. Royal Astron. Soc., Vol. 73, 125).

The assumption that the average position

of the two reduced first order images is equivalent to the true position of the central image was tested. A least square solution was performed on the difference between this average position and the central image of a second shorter exposure of the same region but shifted by several mm on the plate. The results indicate that the assumption is valid.

PROCEEDINGS, 1971–1972

IMAGE ROOTS OR IMAGE NUMBERS. Katherine H. Barringer. Dept. of Mathematics, Central Va. Cmnty. Col., Lynchburg VA 24502

In sketching quadratic functions where the graphs are parabolas, we find the real roots by solving for the zeros of the function $y = ax^2 + bx + c$, where $(b^2 - 4ac) \ge 0$. Whenever the discriminant, $\Delta = b^2 - 4ac$, is negative we state that the roots are "imaginary" as the opposite of "real" roots and merely observe that such curves do not cross the x-axis.

To give beginning students a clearer picture of the nature of the parabola that does not cross the x-axis a better choice of words might be that the roots of are "image roots" found where the image of the curve reflected downward from the vertex (as a mirror image) crosses the x-axis. or the image roots would be the points where the curve it-self crosses the "image-axis," drawn parallel to the x-axis at the same distance above the vertex as the x-axis is below the vertex. The distance of each of these image roots on either side of the axis of symmetry is 1/(2a) times the square root of the absolute value of the discriminant. The image roots on the x-axis are the same distance from the axis of symmetry as roots on the image axis.

To graph any quadratic function we first examine the discriminant to determine whether there are real roots. Upon finding $\Lambda < 0$, we would build a table of values, plot the points, and draw the resulting curve, the image axis, and image curve. This can be used to explain to students the nature of un-real roots or unreal numbers.

NEWTON'S METHOD AND THE USE OF DIFFERENTIALS AS APPROXIMATIONS. J. Van Bowen, Jr. Mathematics Dept., Univ. of Richmond, Univ. of Richmond, Va. 23173

The use of differentials to approximate \textbf{y}_0 = $\textbf{f}(\textbf{x}_0)$ is compared to Newton's method of locating the zeroes of $f^{-1}(y) - x_0$

PROPOSED NEW METHOD OF MEASURING MINUTE VARIATIONS IN THE GRAVITATIONAL CONSTANT G. <u>J. W. Beams</u>. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901 A Cavendish type gravitational torsion balance is mounted

on a constant speed rotating table and maintained at a temperature below 20K. The small mass system (several kilograms) is suspended by a torsion free magnetic suspension and the gravitational torque produced by the interaction of the large and small mass systems is balanced by a fine torsion fiber or by a constant magnetic field (possibly produced by a special permanent magnet) acting on a diamagnetic small mass system. Both small and large mass systems are in a high vacuum (less than 10-7 Torr). A change of G in the Newton relation

 $F = G \frac{M_1 M_2}{d^2}$

of one part in 10¹¹ per year should be observed if it exists. Several theories predict a change in G of one part in 10^{10} .

MOMENTUM AND SOUND. <u>D. Rae Carpenter, Jr.</u>, Va. Military Inst., Lexington, VA 24450.

A revival of interest in physics lecture demonstrations has occurred in recent years. Apparatus for a number of demonstrations has been added at the VMI with the assistance of the Physics Revitalization Program sponsored by the National Science Foundation through the Regional Educational Laboratory for the Carolinas and Virginia.

Longitudinal waves in 1/2" aluminum rods of various lengths can be excited by stroking the rod longitudinally with the fingers. Transverse waves can also be demonstrated.

The slow absorption of a large momentum by a small force can be demonstrated by throwing an uncooked egg into a large bedsheet.

Momentum increase for a light aluminum cart

rolling on a long track can be demonstrated by allowing a group of fifteen 2 1/2" diameter steel balls to roll from the rear of the cart, each giving an impulse to the cart as it leaves.

Physics Demonstration Experiments (The Ronald Press, New York, 1970) p. 496.

²Ibid. p. 188-9

NEGATIVE THERMAL EXPANSION OF RUBBER. Michael H. Coopersmith*. Dept. of Physics, Univ. of Va., Charlottesville, Va. 22901

The negative thermal expansion of rubber is demonstrated by means of two devices. The first is a thermometer using rubber as the substance with the thermometric property. The second is a heat engine with rubber as the working substance. The heat engine can also be used to demonstrate an apparent violation of the second law of thermodynamics. It can be made to appear as a perpetual motion machine of the second kind.

PROJECTION OF OSCILLOSCOPE PATTERN ON SCREEN FOR DEMONSTRA-TION LECTURES. G. W. Crawford, Dept. of Physics, College of William and Mary, Williamsburg, Va. 23185 While the oscilloscope is an indispensible instrument in

the study of physics, especially where wave forms are to be analyzed, its use in lecture for large groups of students is limited by the small size of the picture tube. By attaching an army surplus Aero-Ektar f 2.5, 178mm lens in front of the tube of a five-inch high intensity oscilloscope so that the lens can be moved for focussing it is possible to project the oscilloscope pattern on a screen. The projection may be enlarged to one meter or more in diameter. For optimum results the room should be completely darkened and the oscilloscope operated at its highest intensity. The adaptation is very useful in the study of sound where characteristic musical notes may be played through an audio system such as a tape recorder and simultaneously projected on the screen for the audience to observe the wave pattern of the specific sounds.

USE OF THE LASER TO DEMONSTRATE BASIC PRINCIPLES OF OPTICS IN LECTURE DEMONSTRATIONS. G. W. Crawford, Dept. of Physics, College of William and Mary, Williamsburg, Va. 23185

One of the chief difficulties encountered in demonstrat-

ing principles of optics such as refraction and reflection in lecture is the inability to show the actual path the ray of light takes. Utilizing a helium-neon laser such as the Metrologic Model 410 and containers filled with water in which a small amount of Pream or similar material has been dissolved it is possible to show the path of the beam through a tank of water or a large prism filled with water. If smoke or chalk dust is introduced in the path of the beam its path before entrance and after emergence are easily seen. The minimum angle of deviation of a prism, total internal reflection, refraction, etc. may be demonstrated. For optimum results the lecture room should be sufficiently lighted to make the objects through which the beam passes visible. The tanks should be thin or the beam should be passed through the water near the audience side of the tank to minimize the absorption of the scattered beam.

IMPROVED DENSITY MEASUREMENTS ON XENON AS A FUNCTION OF DEPTH NEAR THE CRITICAL POINT. <u>D. L. Deardorff</u> and D. V. Ulrich, Department of Physics, Bridgewater College,

Bridgewater, Va. 22812
Described is the measurement of densities of xenon near the critical point as a function of depth in a sealed glass cell 1.5 mm diameter by 1.5 cm long. Densities were determined with a Beams magnetic suspension densitometer constructed in this laboratory through measurement of currents required to leviate a Hy Mu "80" magnet 0.3 mm in diameter and 0.8 mm long. Temperatures were controlled and relative temperatures measured to * 0.001°C and maintained for 20 hours before readings were taken. Between the temperatures of 16.519°C and 16.627°C, 36 density-depth curves were obtained. The values of T and p were observed to be 16.572 * 0.05°C and 1.117 *0.005 g/ml, observed to be 16.5/2 * 0.05°C and 1.11/ * 0.005 g/m1, respectively. Relative pressure values as a function of depth were calculated; for $\Delta h = 2$ mm at T_{\star} , $\Delta \rho / \rho = 0.085$ and $\Delta p = 0.2$ matm. Values of β , defined by $\rho_L - \rho_G \ll (T_C - T)^\beta$ were determined to be 0.335 for $T_C - T \geqslant 0.020$ °C and 0.167 for $T_C - T \ll 0.020$ °C. Appreciation is expressed to the National Science Foundation for its support of this work.

THE (p,π^+) and (π^+,p) REACTIONS and NUCLEAR STRUCTURE*. J. M. Eisenberg, J. V. Noble and H. J. Weber, University of Virginia.

Theoretical and experimental developments involving the (p,π^+) and (π^+,p) reactions are reviewed. Recent experimental developments would appear to indicate that these reactions may be capable of yielding fairly detailed information on nuclear structure. Unfortunately, the existing theories are quite inadequate to account for the data, presumably due to aspects of the reaction mechanism which are not sufficiently understood. The present work attempts to improve on this situation by utilizing the Sopkovitch approximation to handle effects due to the distortion of the pion and proton waves. This approach has the great virtue that it eliminates sensitive and unknown effects of off-shell behavior. Quantitative results are presented and compared with experiment.

*Work supported in part by the N.S.F.

THE 40-INCH McCORMICK ASTROMETRIC REFLECTOR. Fredrick, Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

The new 1.03 meter McCormick Astrometric Reflector is innovative in many respects. Optically it uses an unique design by Professor James Baker. The drive is a roller drive proposed by the author and incorporates stepping motors. Electronically it is designed to be controlled by a computer in a step by step process. Its large field as well as scale make it suitable for a variety of astrometric problems including the intercomparison of the radio and optical coordinate systems.

SHORT TERM VARIATIONS IN THE SPECTRUM OF ALGOL. D. M. Gibson*. Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

Spectrograms of the eclipsing binary Algol (β Per) have revealed complex variations in the Hydrogen line profiles with a time scale of tens of minutes.

The spectral plates (Kodak 103-a0 emulsion) were secured at the Fan Mountain Observing Station of the University of Virginia. A grating spectrograph mounted to the 80 cm telescope gave a dispersion of 22 A/mm with a resolution of 0.8 Å. Microdensitometer tracings were carried out at the Dept. of Astronomy.

The observations were carried out on the nights of Feb. 11 and 14, and made simultaneously with the NRAO interferometer observations of Wade, Hjellming, and Webster. Radio flares occurred on both nights.

Soft emission and absorption appeared superimposed on the red edge of the Doppler cores of $H\beta$ and $H\gamma$. No unusual activity occurred on the blue edge. The lack of correlation with the orbital period and the positive Doppler velocities (150 km/sec) determined from the red-shifts of the features are consistent with the infall of matter into the B3V primary. Therefore, this is a new secular variation, different from the emission due to gas streaming at the Lagrange point observed by Sahade and Struve. (The author conducted this work while holding an NDEA Type-IV Fellowship).

AN ANOMALY IN THE H-BETA INDEX IN F AND G STARS AT HIGH GALACTIC LATITUDES. William Gutsch*. Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

Stromgren uvby and $H_{\rm g}$ photoelectric photometry has been completed in 26 regions near the north galactic pole at Kitt Peak National Observatory. Under study are 187 field stars down to apparent magnitude V = 13.835 in the range $0.000 \le b - y \le 0.400$. Analyses thus far conducted indicate an anomaly in the H $_{\beta}$ index of these stars in the sense that the program stars on the average show consistently lower ${\rm H}_{\rm S}$ indices for their colors than corresponding members of the Hyades and local field stars.

This work was conducted under NSF grant GP-18162.

RADIO VARIATIONS OF BETA PERSEI AND BETA LYRAE. R. M. Hjellming*, C. M. Wade* and E. Webster*. Nat. Radio Astronomy Observatory, Charlottesville, Va. 22901

Va. 22901
Radio emission has been detected from the eclipsing binary stars β Persei(Algol) and β Lyrae. During the first observations, β Lyrae showed no variation in signal whereas β Persei was clearly variable in strength. Further observations of β Persei with the NRAO interferometer operating at 8085 and 2695 MHz reveal frequent radio flaring over a time scale of a few hours. The spectral index has been observed to vary between spectral index has been observed to vary between -0.8 and +0.7 with the former dominating during the major flares.

The Beta Lyrae system faded to a flux level below the detection limit of the instrument, thereby proving that it is also a variable radio

source.

A REALISTIC ACTIVE-PHASE MODEL OF GALACTIC NUCLEI. Kenneth C. Jacobs*. Dept ville, Va. 22903 Dept. of Astronomy, Univ. of Va., Charlottes-

Since their recent discovery, quasars and active galactic nuclei (including Seyferts)---though conjectured to be interrelated---have eluded all attempts at theoretical interpretation. In addition, we are confronted by the possibility of numerous energetic pulses of gravitational radiation emanating from the center of our Galaxy. Among the less-exotic models advanced to explain and relate these observed phenomena is the dense-stellar-cluster model, wherein might occur numerous supernovae, the formation of many neutron stars, stellar collisions and disruptions, and other violent activity leading perhaps to gravitational pulse emission and the production of intense radio sources.

Here we describe ongoing research into the behavior of such a superdense stellar cluster, from its initial formation, through a (conjectured) brief active phase, to its final state. The feature of fundamental importance in this "realistic" model is the inclusion of rotation---the cluster possesses net angular momentum. The surprising consequences are elucidated in some detail.

BROAD BACKGROUND COMPONENT OF INTERSTELLAR HYDROGEN. J. W. Mast*. Leander McCormick Observatory, Univ. of Va., Charlottesville, Va. 22903

An analysis of the diffuse, high-temperature, opticallythin component of neutral atomic hydrogen is based on a survey of 21 cm radiation at intermediate and high galactic latitudes. A computer was used to fit Gaussian components to the observed emission profiles. The broad optically-thin component appears in almost every profile and in most cases one or more narrower cloud components are also present. At intermediate galactic latitudes the effect of differential galactic rotation is clearly present in the mean velocities of the optically-thin component. The mean column density of the optically-thin component is 2 x 10^{12} cosec (b) atoms cm² the optically-thin component is 2 x 10 cosec [a] around the for a large area of the galaxy. However at positive galactic latitudes, b > 35° , and at intermediate latitudes in the range of galactic longitude, $1 = 190 - 270^{\circ}$, the mean column density is 1×10^{10} cosec [b] atoms cm⁻².

GRAVITATIONAL RADIATION FROM A HYPERBOLIC KEPLERIAN ORBIT OF TWO STARS. H. A. McAlister*. Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

The equation of the orbit of two stars undergoing hyperbolic scattering about their center of mass is obtained from the general solution to the orbit by expressing the orbital angular momentum and energy in terms of the impact parameter and relative velocity at effectively infinite separation. This procedure additionally yields the orbital eccentricity and the asymptote angle of the relative hyperbolic orbit in terms of these quantities.

The quadrupole moments are computed from the hyperbolic orbit equation and arc shown to have the same orbital position angle dependence as those for masses in elliptical orbits. The moments are then applied to the power equations which result from a linearization of the equations of general relativity, and power patterns for non-relativistic encounters are calculated showing maximum beaming at the poles of the orbit.

Finally, situations are sought for which the power output is compatible with that being observed by Weber. Weber's pulses are thought to be coming from the galactic center and it is of interest to see if a highly evolved, dense star cluster at the nucleus (in which hyperbolic en-counters occur frequently) might explain these observations.

A BLINK PHOTOMETER FOR THE KLINK OBSERVATORY.

J. A. McLeod* and A. C. Miller, Dept. of Physics,
Va. Mil. Inst., Lexington, Va. 24450.

A Blink photometer was recently built for the

VMI Klink Observatory. This uncooled, battery operated instrument was specially designed for the 16-inch, f/8 Newtonian reflector.

The Blink photometer operates by charging a capacitor from the output of the 931A or 1P21

photomultiplier tube and discharging through a neon tube at a rate proportional to the intensity of the incident star light. See A Minimal Cost Photoelectric System, T. R. Cram and T. E. Houck, 1969, Nat. Radio Astron. Obser.

This photometer will allow UBV measurements

to be made of variable stars of 6th magnitude with

an accuracy that approaches .01 magnitude.

The chief advantages of the Blink photometer are the simple design and the low cost.

PROGRESS REPORT ON FIBER RESEARCH AT OLD DOMINION UNIVERSITY. J. B. Miles and D. E. Troyer, Jr. Dept. of Physics, Old Dominion Univ., Norfolk, VA 23508

Research which has been done on the bending stress-strain and recovery of a variety of synthetic fibers since our last report to the Virginia Academy of Sciences is reviewed. In-cluded is an analysis of the bending moment vs. curvature curve based on the measured tensile and compression stressstrain curves parallel to the fiber axis, which includes the expected shift of the neutral axis, and an experimental confirmation of this analysis.

BERYLLIUM-HYDROGEN COMPLEXES IN SILICON. H. T.

Morgan*, Physics Dept., Va. Military Inst., Lexington, VA 24450 and T. E. Gilmer, Jr., Va. Polytechnic Inst., Blacksburg, VA 24061. Single crystal silicon, containing the impurity beryllium, was implanted with energetic hydrogen ions produced by a Van De Graaff accelerator. Infrared absorption spectra of the implanted carples display two rew. sets of implanted samples display two new sets of absorptions caused by the implantation. These two sets of absorptions are studied as a function of initial beryllium content as well as post irradiation heat treatment and are believed to be due to two different beryllium-hydrogen acceptor centers formed in silicon crystal. The ionization energies for these centers were determined to be 92.0 mev and 43.4 mev respectively and a model for each center has been developed in accordance with the experimental observations.

A FURTHER STUDY ON THE SEPARATION BY BALMER-LINE PHOTOMETRY OF HIGH AND LOW LUMINOSITY STARS HAVING H-ALPHA IN EMISSION. Charles D. Smith*. Dept. of Astronomy, Univ. of Va., Charlottesville, Va. 22903

Photoelectric Balmer-line alpha and beta indices have been determined for 150 H-alpha emission-line stars of unknown luminosity in a further investigation of a method for separating normal Be stars and early type Ia super-giants. Abt and Golson (Astrophys. J. 143, 306, 1966) found the technique was successful in separating about two-thirds of the Be stars and two-thirds of the supergiants from a mixed sample of bright stars ($m_V < 6.5$). The present study of stars with 7 < $m_V < 10$ shows a somewhat better separation between the two groups but with some ambiguity caused by objects with peculiar luminosity and spectral characteristics. It is shown that the expected number of supergiants found by this method is dependent on varying stellar density distribution and on the increasing importance of interstellar absorption for more distant

TWO GROUPS OF PLANETARY NEBULAE? H. Smith Jr. *. Astronomy, Univ. of Va., Charlottesville, Va. 22903

A growing body of evidence suggests that planetary nebulae do not comprise a single, homogeneous class of objects. Although blurred by pronounced evolutionary changes, a distinction can be made between two groups on the basis of Doppler expansion velocities and magnitude differences between central stars and respective nebulae (distance-independent quantities). The separation correlates well with known differences in central star spectral type and nebular chemical composition. A difference in nebular mass is marginally indicated. A distance scale has been derived from evolutionary relations between nebular radius and expansion velocity for the two groups. Comparison is made of the predicted distribution of nebular radii with that found for the solar neighborhood and with the angular-radius distribution of nebulae in the direction of the galactic center.

PRACTICAL ASSORPTION CURVES FOR CALIBRATING DIAGNOSTIC X-RAY MACHINES. E. E. Stickley and A. M. Strash. Radiation Physics Division, Med. Col. of Va. Commonwealth Univ. Richmond, Va. 23219

Measurements of x-ray output and transmission through aluminum and copper absorbers are programmed to give peak kilovoltage and radiation quality values for diagnostic x-rays delivered to the skin of patients or to the image transducer. This affords an effective comparison of performance parameters between different machines or with standard values. Other factors also evaluated by computer include timer-control function and adequacy of current control adjustments. Further extensions of these methods are to test beam size and direction, including accuracy of alignment of the x-ray tube insert. Standardization curves and their fitting to data from individual installations will be illustrated. The objective is to develop the most direct and practical approach for determining compliance with the legal radiation rules and regulations and establishing consistency with the requirements of good practice.

VISUAL AIDS FROM AN OVERHEAD PROJECTOR. Lewis W. Webb, Jr., Dept. of Physics, Old Dominion University, Norfolk, Va. 23508

The use of an overhead projector as a teaching tool is often neglected by college physics teachers. A number of examples of transparencies made from printed material, photographs, and other materials are to be shown as well as hand made drawings, sketches, etc. Processes for making the transparencies quickly and easily will be demonstrated. Several devices designed for use with the overhead

projector, which can be constructed by the instructor using simple tools and materials that are readily available, will be shown. These include a ripple tank, a projection galvanometer, a magnetic field visualizer, a shadow wave machine, and others.

THE ROLE OF ABSTRACTION IN QUANTUM MECHANICS. P. F. Zweifel Department of Physics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24601

Quantum Mechanics is a unique subject in physics curricula because of the number of abstract concepts which play a prominent role in the development and understanding of the theory. An example is the so-called "gedanken experiment" used to derive the uncertainty principle. Another example is what I call the "gedanken measurement" which helps clarify the concept of the collapse of the state vector, which in turn leads to the introduction of non-causal effects into quantum mechanics. A more mathematical example involves the "Abstract Hilbert Space" of Dirac which must be "realized" before any actual calculation can be carried out.

I feel that these abstractions are not necessary, and serve often to confuse the student. Thus, I propose more concrete concepts to replace these abstract notions.

Section of Biology

Fiftieth Annual Meeting of The Virginia Academy of Science May 3–5, 1972, Lexington, Virginia

SOME PRELIMINARY HISTOLOGICAL OBSERVATIONS OF THE HINDGUT OF CALLINECTES SAPIDUS RATHBUN. J. G. Aldridge* and J. E. Pugh. Dept. of Biol., Christopher Newport Col., Newport News, Va. 23606

The hindgut of Callinectes sapidus Rathbun passes from the midgut in a generally straight line through the abdomen between the hepatopancreatic lobes and under the pericardium terminating on the ventral surface of the telson. Intimately associated with the gut are two glandular elements; the cephalic intestinal gland which partially encircles the midgut-hindgut junction and the posterior tubular gland which enters this junction under cover of the cephalic gland. The laminated papillated cuticle lies on the free surface of the tall columnar intestinal epithelium, which in turn rests upon a basement membrane. The submucosal layer is composed of scattered connective tissue elements as well as longitudinal striated muscle. The latter are apparent in the intestinal folds and probably govern the diameter of the gut lumen. The entire gut is loosely enveloped by circular muscles, connective tissue and cushion cells.

OSMOTIC RESPONSE OF THE BLUE CRAB, CALLINECTES SAPIDUS, TO TEMPERATURE AND SALINITY STRESS. L.M. Amende and C.P. Mangum (Sponsor), Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

Blue crabs collected from the Chesapeake Bay at 14-18% salinity and 25-28°C. during August 9-27,1971 were subjected to salinities of 1.5,13, and 25% and temperatures of 3,15, and 30°C. to determine effects on osmoregulation. The crabs were divided by sex and size (40-70mm,80-110mm) and a 24-hour adjustment period was allowed.

The blue crab is an hyperosmotic regulator at these salinities and temperatures, although slight hypoosmotic regulation appears at $4^{\circ}\mathrm{C}$. in 25% salinity. Analysis of variance of the data show that effects of temperature, salinity, and size are significant, but that effect of sex is not. Temperature has an inverse effect on osmoconcentration at 15 and 30° C., except at 1.5% salinity. At 1.5%, highest osmoconcentration is attained at 30°C., an interesting response since invasion of freshwater usually occurs during the hot summer months. The $1^{\circ}\mathrm{C}$. salinity combinations were too great a shock for the smaller crabs as they died before measurements were made. The larger crabs also showed shock reactions to this low temperature by low osmoconcentrations. Maximum osmoregulation for both large and small crabs occurs at 15°C. from 15-30% salinities. The least regulation for both large and small crabs occurs at 15°C. for 1.5-15% salinities.

THE EFFECTS OF OIL ON THE GILL FILTRATION RATE OF MYA ARENARIA. Gilbert E. Anderson*. Col. of William & Mary, Williamsburg, Va. 23185

The acute effects of oil pollution on the soft-shelled clam, Mya arenaria, were studied by measuring changes in turbidity of graphite-particle suspensions as indices of filtration rates. A heavy fuel oil, Bunker C, was used in all experiments. Filtration rates were measured during three-hour intervals before and after exposure to either 0.9 per cent oil-water emulsions or to 0.9 per cent extracts of oil in water. A paired observations test indicated significant rate increases in clams exposed to the emulsions, but there were no definite trends in the responses of clams exposed to the oil extract.

CHARACTERIZATION OF SPINACH CHLOROPLAST LAMELLAR MEMBRANE PROTEIN USING SODIUM DODECVISULFATE GEL ELECTROPHORESIS.

M. W. Banschbach* and J. L. Hess, Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A β -carotene-lamellar protein fraction has been obtained from spinach chloroplast lamellar membranes using sequential extraction with 50, 70, 75 and 80% (v/v) acetone: water solutions. Interaction between β-carotene and lamellar protein in this fraction was evaluated using spectral analysis, proteolytic hydrolysis and discontinuous sucrose density gradient centrifugation. These techniques established that interaction between β-carotene and lamellar protein does occur; however, the specificity of this interaction could not be determined using these techniques. Sodium dodecylsulfate (SDS) disc gel electrophoresis was employed to help evaluate the specificity of $\beta\text{-carotene-lamellar}$ protein interaction. Two samples of lamellar protein, one with β -carotene, the other with β -carotene removed by acetone extraction, were solubilized in 1% SDS, 0.01 M Tris-C1, pH 8.0. Approximately 95% of protein was solubilized; protein bound to $\beta\text{-caro-}$ tene was not solubilized. A discontinuous buffer SDS gel electrophoresis system has been successfully used to obtain protein patterns for both samples. Acrylamide concentrations varied from 7% to 11% and running pH from 9.05 to Proteins with molecular weights from 15,000 to 50,000 have been observed.

THE EFFECT OF A TRYPTOPHAN-FREE DIET ON SEROTONIN KINETICS IN THE RAT DUODENUM. <u>B. A. Beaver</u>, T. D. Kimbrough. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220 Gershon, et al., have recently determined that serotonin is selectively taken up by certain elements of the myenteric plexus. If serotonin is the specific neurotransmitter in these neurons, causing transmission of the action potential to the longitudinal muscle layer in which this plexus is embedded, then a deficiency of tryptophan intake in the diet should cause a noticeable decrease in the motility of the muscle. Young male and female Wistar rats were kept on a tryptophan-free synthetic crystalline amino acid diet for a period of two months. The animals were sacrificed and the first 2 cm segment of duodenum was excised and connected by a 1.5 ounce Statham strain gauge to a recording polygraph. The gut strips were constantly perfused at 37° in a 0.006 M glucose solution 95% saturated with oxygen. Time was allowed for the tissue to adjust. The most active oneminute period was evaluated by measuring the total area under the curve with a compensating polar planimeter. The results showed a general overall decrease in intestinal motility, with a noticeable decrease particularly in the activity of the longitudinal muscle layer as compared to control readings. The regular pattern of rythmicity of the circular muscle layer was maintained. Attempts were made to restore longitudinal motility by the addition of serotonin to the perfusate. In several instances motility was significantly restored.

AN EVALUATION OF THE SWIFT METHOD OF CLEANING DIATOM FRUSTULES. Charles W. Belin, Jr. and Jacques S. Zaneveld, Institute of Oceanography, Old Dominion University, Norfolk, Va. 23508.

A quantitative and qualitative study of the Swift method (1967) of removing epiphytic diatoms was undertaken using as host plant <u>Sargassum fluitans</u> Børgesen, recovered from the western Sargasso Sea at 35° 47.1' N. lat., 75° 06.3' W. long.

Counts of epiphytic diatoms were made before illumination with ultraviolet light, after illumination, and of the water in which the algae had been illuminated. Mean epiphytic diatom densities computed from these counts were, respectively, 1992.5 diatoms per gram, 76.7 diatoms per gram, and 2222.4 diatoms per gram of \underline{S} . fluitans. The purpose of these counts was to derive statistical information to determine whether there was a change in the number of epiphytes as a result of the oxidative nature of the illumination.

The results of this experiment demonstrate that the Swift method is an extremely efficient and reliable method for stripping diatoms from aquatic plants to which they adhere. Also, the method appeared to be very effective in cleaning the exterior of the frustules, facilitating identification of the specimens.

WINTER MORTALITY OF THE LANDLOCKED ALEWIFE, ALOSA PSEUDO-HARENGUS, IN CLAYTOR LAKE, VIRGINIA. J. L. Boaze and R. T. Lackey*. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

During the winter of 1970, 1971, and 1972, large numbers of dead or dying landlocked alewives appeared below the Claytor Lake hydro-electric plant. The dead or dying alewives, the majority of which were young-of-the-year, were in the process of a seasonal downstream movement seeking warmer water, when they were siphoned out of the lake by penstock tubes. (Aided by Commission of Game and Inland Fisheries)

SOME GENETIC CHARACTERISTICS OF A CULTURAL-RELIGIOUS ISCLATE: ABO BLOOD GROUPS AND DERMATCOLYPHICS. K. K. Brubaker, P. Magaly and A. Kolby Dept. of Life Sciences, E. Menn. Col., Harrisonburg, Va. 22801

Data on ABO blood type of 12Ll students attending Eastern

Data on ABO blood type of 12hh students attending Eastern Mennonite College indicate that cultural-religious factors seem to have operated quite successfully in maintaining a gene frequency which resembles that of their Swiss-German ancestors more than that of their North American neighbors, even though the original settlers came to Pennsylvania before the Revolutionary War.

Dermatoglyphic studies indicate sub-groups within the Mennonite-Amish population when gene pools in various areas are compared. The age of the mother at birth of the subject may also have an effect on dermatoglyphic pattern such as frequency of loops and whorls.

MEIOTIC DRIVE IN COCKROACH CHROMOSOME TRANSLOCATIONS. D. G. Cochran. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Chromosomal meiotic drive has been shown to occur in certain translocation stocks of the German cockroach, Blattella germanica (L.). It can be detected cytologically at metaphase I and at late prophase II. Counts of large numbers of cells have been made to obtain an estimate of the drive situation for each of several translocations. In certain instances biological data have also been obtained to check the correspondence between cytological expectation and biological reality. The results were variable, and in one case a possible explanation for a discrepancy was discovered.

The significance of meiotic drive for experiments involving genetic manipulation of population size will be discussed. (Aided by NSF grant GB28954).

REGENERATION IN THE AFRICAN LUNGFISH PROTOPTERUS UNDER CONDITIONS OF FASTING AND ESTIVATION. Elizabeth B. Conant, visiting Research Associate, Department of Biology, Univ. of Virginia, Box 966, Charlottesville, Va., 22901

Normal regeneration of extremities by well-fed lungfish in water involves a 2-3 week latent period followed by first increasing and then decreasing growth. The growth rate tapers off after 3-4 months as the new structure approaches or surpasses 100% replacement of the part removed. Pectoral limb regeneration followed in 3 starving Protopterus revealed a latent period and an early growth period roughly comparable to those of the controls, but later growth was significantly slowed and replacement was only 50--70% of the amount removed after 7-10 months of fasting. To investigate the effects of estivation on regeneration of limbs and tail, 15 animals were induced to estivate at varying stages of regrowth. When estivation interrupted either the latent period or the early stages of regeneration, further regeneration in the mud was limited sharply. When estivation was induced in animals whose extremities averaged 30% or more replacement growth, some or all appendages actually shrunk in size during the 4-5 months in the mud.

EFFECT OF TEMPERATURE ON ACTIVE AND RESTING

EFFECT OF TEMPERATURE ON ACTIVE AND RESTING
METABOLISM IN POLYCHAETES. P. E. Coyer* and
C. P. Mangum. Dept. of Biology, Col. of William
and Mary, Williamsburg, Va. 23185
The following proposal is being investigated
using three species of polychaetes: resting
metabolism of intertidal invertebrate organisms remains thermally insensitive over a wide environmental range. Polychaetes were chosen as representative animals because of their characteristic patterns of activity and rest during ventilation which result in rapid and slow rates of oxygen consumption. To answer the question of active and resting metabolism, temperature coefficients for two species <u>Diopatra cuprea</u> and <u>Glycera dibranchiata</u> have been computed for a wide temperature range. In both animals these metabolic rates were related previously to their behavior cycles during tube irrigation. No Ω_{10} 's of 1 for resting metabolism were observed in our experiments over a wide temperature range and both active and resting $\mathbf{Q}_{\mathbf{10}}\mbox{'s}$ show thermal sensitivity. RESPONSES OF THE RIBBED MUSSEL, MODIOLUS DEFISSUS, TO LOW SALINITIES. P. deFur and C. P. Mangum, Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 20185.

The investigation concerns a population of <u>Kodiolus demissus</u> found on the York River. Field data were collected over an 18 month period and experiments were conducted to compare the effects of different salinities on the survival, filtration, and

heart rates in an estuarine population and a marine population.

Over approximately 12 months, the M. demissus population on a 1 square meter plot showed a 25% increase in numbers and a mortality of about 11% per year. The salinity during this time ranged from 3.7 - 11.1 /oo. Smaller numbers of mussels were found upstream where the salinity is lower.

The filtration rates in York River mussels are lowered at 5 /oo and less; the rates for marine mussels are lowered at 15 /oo and less. The survival for marine mussels in all salinities was lower than that for York River mussels. Heart bests

ities was lower than that for York River mussels. Heart beats of York River mussels decreased in amplitude and frequency sterting at salinities of 5/00 and were seriously impaired below 3/00. Marine mussels exhibited decreased amplitude and frequency of heart beat at salinities 15/00 and 10/00 and serious lowering at 5/00 and less.

The York River mussels seem to be highly adapted to very low salinities, which apparently permits extension of the species range into brackish waters.

FARMING CHANNEL CATFISH IN VIRGINIA. V. M. Douglass, and R. T. Lackey. Div. of Forestry and Wildlife Sciences, V.P.I.&S.U., Blacksburg, Va. 24061

The production of channel catfish has become a multimillion dollar industry in the United States during the past decade. An estimated 55 million pounds of farm-grown catfish were produced in the United States in 1970. Research on the practicality of raising channel catfish in Virginia for supplemental agricultural income was initiated in 1968. These research efforts showed catfish farming to be feasible, there are several technological problems to be worked out, especially in the area of cage culture. Some conclusions are (1) the production of market-sized channel catfish is economically and biologically feasible, (2) there are existing ponds suitable for commercial production, and (3) under normal conditions and with good management, reasonable returns can be realized. In addition, a promising future for Virginia catfish farming related to the use of northern strains. These catfish might be better adapted to Virginia's cooler water. Thus, the growing season could be extended, resulting in better production. Furthermore, the feasibility of raising catfish on a commercial scale will be investigated. The results will determine the kinds of factors a farmer should consider before entering the catfish farming business in Virginia.

POSSIBLE INVOLVEMENT OF BLOOD CELLS IN THE SYNTHESIS OF

COCKROACH CUTICLE PROTEINS. J. G. Geiger and R. R. Mills. Biology Dept., Va. Commonwealth Univ., Richmond, Va. 23220
The American cockroach molts approximately every 28 days at 25° and a new cuticular matrix of chitin and protein is formed each time. The cuticle proteins are normally transported and stored in the haemolymph (blood) before being taken up into the integument. Carbon-14 leucine is incorporated into freely circulating blood and fat body cells at the time of the molt and subsequent injection of the cellular ¹⁴C-extracted protein into other animals results in labeled blood cells and cuticle. These data suggest that circulating cells are capable of synthesizing potential cuticle proteins.

COMPARATIVE CHANGES IN THE ORGANIC PRODUCTIVITY OF AN IMPOUNDED RESERVOIR FOLLOWING ARTIFICAL DESTRATIFICATION. C. L. Gibbin* and C. M. Weiss.* A comparison in the variation of organic productivity of the periphyton of an impounded reservoir was examined from 1969 to 1971. Comparison of chemical oxygen demand (C.O.D.) of the control year (1969) and the two years of artifical destratification (1970-1971). Stratification was accomplished by air hoses. Results indicated formation of an almost completely fication was accomplished by air hoses. Results indicated formation of an almost completely homogeneous nutrient pool as well as a more uniform dispersal of dissoved oxygen. While values of maximum productivity decreased with periods of increasing artificial destratification, the area of overall productivity increased. (Aided by Project No. B-007-NC, Matching Grant Agreement No. 14-01-0001-1933 of the Office of Water Resources Research, Department of the Interior through the Water Resources Research Institute of the University of North Carolina as authorized under the Water Resources Research Act of 1964.) the Water Resources Research Act of 1964.)

TOXICITY OF ZINC SULPHATE TO ISONYCHIA SADLERI (EPHEMEROPTERA: ISONYCHIIDAE) FROM TWO STREAMS. B. C. Gregg, E. F. Benfield, Biology Department, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061 Nymphs of the mayfly Isonychia sadleri from two streams differing in hardness, alkalinity and pH were exposed to zinc sulphate in a strength to extablish 96 hm. Median

zinc sulphate in an attempt to establish 96 hr. Median Tolerance Limits. In addition to the regular assays reciprocal assays were conducted in which nymphs from one stream were exposed to zinc dissolved in water from the other streams.

Nymphs from the soft water stream had the highest TL_m values, nymphs from the hard water stream had the lowest TL_m 's and nymphs used in the reciprocal test exhibited intermediate TL_m 's. Two size classes of nymphs were employed in all assays. In all test the TL_m 's for the smaller nymphs were lower than those for the larger nymphs.

THE EFFECT OF DIMETHYFORMAMIDE ON Meriones unguiculatus. W. S. Hastings, T. D. Kimbrough and G. C. Llewellyn, Dept. of Biology, Va. Commonwealth Univ. and C. E. O'Rear and F. W. Rea, Va. Dept. of Agriculture and Commerce, Richmond, Va. 23220

The insoluble nature of aflatoxin B $_{\parallel}$ in most injectable solvents causes a considerable problem when acute quantities of such toxins are administered. Dimethylformamide (DMF) is one solvent in which such toxins are highly soluble but, unfortunately it is also a mild carcinogen. A common practice has been to administer toxins in 0.1 to 0.2 ml of DMF, which has been considered an acceptable level for most rodents and fishes. This level is apparently in the LD50 range for gerbils. Our studies showed that intraperitoneal injections, subcutaneous injections and consumption via drinking water, all caused similar toxic responses. Catheter intubulations of DMF volumes in excess of 0.12 ml/adult animal also caused lethality. It is currently recommended that for minimal liver pathology, DMF be administered in the drinking water in concentrations not exceeding 1% by volume for not more than 60 days.

A COMPARATIVE STUDY OF THREE FRESH-WATER SURFACE MICROLAYER SAMPLERS. R.F. Hatcher* and B.C. Parker. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060.

The study of fresh-water surface microlayers is a largely unexplored area in aquatic sciences. We know from the literature that marine surface microlayers differ significantly from subsurface water only a few centimeters below. However, there is very little published data on fresh-water surface microlayers. To date, there are two reported methods of collecting surface microlayers, a surface sampling drum (SSD) designed by Harvey (1965) and a surface sampling screen described by Garrett (1966). Although both of these devises are currently being used by various investigators, to our knowledge, no comparative study has been done to ascertain the relative effencies of each technique. This paper will show data comparing the relative efficiencies of the SSD and the SSS as well as a third surface sampling devise of our own design, the surface sampling tray (SST). (Aided by OWRR grant A-O37-Va.)

THE INTERRELATIONS OF URINARY CATIONS AND URIC ACID IN THE (GALLUS DOMESTICUS). A. P. Hinton,* R. A. McNabb, and F. M. A. McNabb,* Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Urine was collected from eight roosters, fed low (LP, 11%) and high (HP, 33%) protein diets, and given ad 1ib tapwater (TW) or 1% NaCl solution (SW). Combinations of these regimes provided three groups - HPTW, HPSW and LPTW. Drinking rates increased in the sequence LPTW<HPTW<HPSW. Drinking tap water, HP excreted urine with the highest uric acid and K⁺ concentrations, and lowest Na⁺ concentration. These differences in electrolyte excretion probably represent differences between the diets. On the high protein diet, SW excrete urine most concentrated in Na⁺, least concentrated in K⁺. Concomitant with the increased electrolyte concentration in the urine of HPSW was an increase in the proportion of precipitated uric acid present in the urine. (Aided by NIH Grant AM14991).

THE DISTRIBUTION AND RELATIVE ABUNDANCE OF THREE SPECIES OF JUVENILE ALOSIDS (FAMILY CLUPEIDAE) IN THE JAMES RIVER, VIRGINIA 1969 to 1971. W. J. Hogman* and J. Davis, Va. Inst. of Mar. Sci., Gloucester Point, Va. Data from experimental trawling by the Virginia Instination

Data from experimental trawling by the Virginia Institute of Marine Science are presented for young of the year Alosa aestivalis (blueback herring), A. pseudohapernys (alemifo) and h. sanidissima.

rengus (alewife) and A. sapidissima.

Th Aug. and Sept. juvenile alosids are concentrated in salinities less than 1 ppt in the James. Peak abundance was between river mile 35 and 75 with numbers falling rapidly in proximity to Richmond. Blueback tend to utilize the lower river (mile 30 to 50) more than alewife or shad. No significant differences were found between numbers captured at the surface and midwater. Bottom tows always yielded few juvenile alosids.

The abundance of each species did not differ significantly between the years (F=2.33,p>.05) nor did the total number of all species combined (F=2.45,p>.05), but the relative abundance between the species did in every year (F=12.37,p\$.01). Blueback made up 81.1 to 96.5% of the juvenile alosids captured in every year, followed by alewife, then shad. Thirty additional tows in the prime nursery area in 1970 yielded an average of 4001 blueback, 398 alewife, and 74 American shad per five minutes with a 10x10 ft Cobb trawl. The corresponding coefficient of variation for the three species was 95%, 139%, and 196% of the mean.

A TREE SURVEY OF THE SOUTH SLOPE OF BRUSHY MOUNTAIN. <u>L. O. Hunt</u>*, and M. L. Slaughter*, Dept. of Biology, Va. Western Community Col., Roanoke, Va. 24015

This survey, using the point quarter method of study,

This survey, using the point quarter method of study, was conducted on the western bank of the Carvin Cove area in Roanoke County. The survey included only trees of at least four inches D.B.H. Quercus coccinea, Quercus prinus, Pinus rigida and Pinus virginiana were the most important in numbers and basal area among thirteen recorded species. Relative dominance and relative frequency in the lower size categories indicated Quercus prinus and Quercus coccinea will maintain dominance in the study area. Relative dominance and relative frequency in the lower size catagories indicated Pinus rigida and Pinus virginiana will maintain an important status in the area in selected habitats.

MANIFESTATIONS OF SENESCENCE IN A SEXUAL RACE OF DUGESIA DORCTCCEPHAIA. M. M. M. Jenkins. Dept. of Biology, Madison Col., Harrischburg, Va. 22801

Carlier studies of sexual races of <u>Dugesia dorotccephala</u>

Earlier studies of sexual races of <u>Dugesia dorotocephala</u> have shown that gametic reproduction is continuous but it eventually culminates in the decline and cessation of reproductive activity. Other signs of ageing also occur during the post-reproductive period. Average gliding length diminishes from 30-35 mm to 25 mm or less under optimal conditions, and renders it impossible to correlate size with age. Reduction is occasionally so proncunced that the animals appear to be juvenile, but their aged state is evidenced by their inability to undergo rejuvenation. Susceptibility to injury increases. Spontaneous lesions rarely heal but result in a pathological separation of the animal into parts. Disintegration commonly follows. Ventral loss of pigment is characteristic. Fartial loss of dorsal pigment, resulting in striping or spotting, may occur. Post-reproductive sterility accompanied by various types of senile change indicate that an organism has a determinate life span and exhibits ageing, but the occurrence of true senescence is best demonstrated by showing the existence of a terminal increase in liability to die. Experimental procedures designed to reveal this aspect of the planarian life cycle should be undertaken. (Supported in part by a grant from Sigma-Xi and NIH grant HO 02217)

REPRODUCTIVE CHARACTERISTICS OF CONFINED COTTONTAIL RABBITS AT DIFFERENT POPULATION DENSITIES. Roy L. Kirkpatrick* and David M. Baldwin.* Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A total of 95 cottontail rabbits was used in three experiments to investigate the effect of density on reproductiv and other selected characteristics. Rabbits were penned in 0.3 acre enclosures at densities approximating 30 or 90 animals per acre for minimum periods of either 27, 71 or 87 days. All females conceived within a period of one week during each of the two years involved and were 13 to 20 days pregnant at the time of necropsy. No consistent effects of density on reproductive characteristics or endocrine organ weights were found in either males or females, although there was a trend toward greater ovarian weights and fewer live fetuses in late pregnancy in the high density females in the two longer term experiments. High density animals also had lower dressed body weights than low density animals. AN INVESTIGATION ON THE POSSIBLE UPTAKE AND SYNTHESIS OF $^{1}_{1}$ C-5-HYDROXYTRYPTAMINE IN THE HEMOCYTES OF $^{1}_{1}$ Periplaneta Americana. C. D. Kirksey, T. D. Kimbrough and R. R. Mills. Biology Dept., Va. Commonwealth Univ., Richmond, Va. 23220

The injection of carbon-14-serotonin into the hemocoel of the American cockroach results in the labeling of both the serum proteins and the hemocytes. Partial purification of the serum proteins by column chromatography on P-10 polyacrylamide gel indicates that all of the label becomes bound to protein or other high molecular weight fractions.

The "bound" radioactive fraction in the blood reaches a peak concentration within an hour after injection and declines slowly thereafter. However, even after 24 hours appreciable label remains.

The significance of the probable serotonin binding to proteins is not yet completely understood but it is tentatively suggested that the protein acts as a carrier for the amine to prevent deactivation.

THE EFFECT OF TRYPTOPHAN-RICH FOODSTUFFS OF VEGETABLE ORIGIN ON SEROTONIN METABOLISM IN MICE. L. Kirksey*and T.D. Kimbrough. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220.

Endogenous and exogenous serotonin are known stimulators of intestinal peristalsis. A study was conducted to determine if exogenous administration of dried foodstuffs having varying concentrations of serotonin would result in a concomitant increase in intestinal motility. For four weeks five groups of Swiss-lebster mice were fed diets supplemented with known amounts of serotonin, varying in concentration from low to high as follows: pineapple, avocado, banana oulp and banana peel. Controls were fed Purina Lab. chow. Each and banana beet. Controls were led during lab. Chow. Sach mouse was sacrificed, and the first 4cm of duodenum removed and connected by a 1.5 ounce strain gauge to a polygraph. But strips were perfused in oxygenated Tyrode's solution at 37.5°C, and gut motility measured in cm2/min. Following equilibration of muscle tissue, measurements of those one minute periods highest in motility (3-4 per graph) were made with a polar planimeter. All experimental cut motility readings were higher than those of controls. Those readings taken between 21-31 minutes following initiation exhibited a marked increase corresponding to concentration of serotonin, ie.,control only increased 8.1 cm²/min; however, pineapole increased by 22.1, avocado by 23.5, banana pulp by 34.2, and oanana peel by 57.6. Thus preliminary findings suggest that exogenously administered foodstuffs high in serotonin (oarticularly banana beel) may result in an augmentation of gut motility in the mouse.

CORRELATION OF PROTEIN-DIPHENOL BINDING DURING THE MOLTING

CYCLE BY THE COCKROACH. G. M. Levison and R. R. Mills.
Biology Dept., Va. Commonwealth Univ., Richmond, Va. 23220
The American cockroach, Periplaneta americana (L.), molts approximately every 28 days when held at 25°. Immediately prior to the molt (ecdysis) the haemolymph protein concentration rises and various diphenols are synthesized from tyrosine. During this period the diphenols bind to the proteins and remain in the haemolymph. At ecdysis, after the old cuticle is shed, the diphenol-protein complex is incorporated into the cuticle intact. Evidence is also presented that a polypeptide hormone known as bursicon mediates this post-ecdysial uptake by increasing epidermal membrane transport.

AN INTEGRATED STUDY OF THE NORTHWEST RIVER AND ITS WATERSHED. Dr. G.F. Levy (Sponsor), Dr. R. L. Ake*, Dr.R.S. Spencer, <u>C. Powell</u>*, L.S. Woodruff*, R. Fennema*, and K. Ashworth*. Dept. of Chemistry, Old Dominion Univ., Norfolk, Va. 23508

An eight-week study of the chemical, botanical, and geological aspects of the Northwest River and its watershed was conducted in an attempt to predict the possible effects on the area of partial deforestation and construction of a dam as well as to learn the methods of coordinating an interdisciplinary project. The chemical investigation entailed analyses for chlorides, nitrates, phosphates, water hardness, alkalinity, pH, and pesticide residues using a combination of wet and instrumental techniques. The objectives of the botanical study were to determine the flora and fauna of the area, to map forest types, and to establish dominant environmental parameters. The geological and hydrological study concentrated upon river flow rates, runoff, drainage basin boundaries, effects on water level by precipitation and wind, and soil sampling. Although the project is still in its initial stages, much insight has been gained into the methodology of interdisciplinary projects. Conclusions regarding the organization, goals, and pitfalls of such integrated studies have proved to be invaluable information for further work. Recommendations are included.

DETERMINATION OF GEOGRAPHIC VARIATION IN ALLELIC FREQUENCIES FOR LEUCINE AMINOPEPTIDASE AND ALCOHOL DEHYDROGENASE ISOZYMES IN CUCURBITA foetidissima. S. R. Lilley; and J. R. Wall. Dept. of Biology, George Mason Univ., Fairfax, Va. An electrophoretic survey of natural populations of C.

foetidissima, a perennial, xerophytic, wide-ranging, and monoecious species of the Southwest, has been conducted in order to examine the electrophoretic analysis of crude seed extracts, and reveals that the species is polymorphic for LAP and ADM. Four different codominant alleles have been identified for the LAF system, Fast, Slow, and in small frequencies, Very Fast and Very Slow. Of the ten phenotypes possible, only the Very Fast/Very Slow form has not been observed. Mountain populations from Bent, New Mexico, Arabela, New Mexico, Tinnie-Hondo, New Mexico, and San Simon, Arizona, exhibit 40%, 19.5%, 45.4%, and 49.4% heterozygotes respectively. Four desert and high plains populations exhibited from 8.3% to 15.9% heterozygotes with an average of 11.5% as compared to the 33.6% average for the montane regions. It is suggested that the montane populations are older stabilized populations, while the plains populations are more likely to derived from recent immigrants and are peripheral.

In general, the geographic variation in ADH polymorphism is inconclusive at this time, with an average for the montane variation being 25.6% and non-montane 23.6%, although the range of variation for the montane was 2.2% to 48%. while the non-montane was from 13.5% to 33.3%.

THE USE OF SERUM CONSTITUENTS OF THE BLUE CRAB, CALLINECTES SAPIDUS, AS INDICATORS OF PHYSIOLOGICAL STRESS. M. P. Lynch and K. L. Webb. Dept. Environmental Physiology, Va. Inst. Mar. Sci., Gloucester Point, Va. 23062

Selected serum constituents (Chloride - Cl; Protein - Pr; Glucose - G_i Ninhydrin Positive Substances - NPS_i and Osmotic concentration - $O\delta m$) of blue crabs subjected to various stresses (red tide, DDT, thermal shock, and hold-ing in aquaria) were compared to "baseline" concentrations of the same constituents in crabs from natural environments. Comparisons are made to seasonal baselines developed by monthly sampling in the same area and to baselines developed by sampling along a salinity gradient from 30 o/oo to essentially fresh water.

Glucose in new year class females and Pr in both males and females were significantly higher in red tide stressed crabs than in baselines. Protein and O.8m were significantly lower in DDT stressed males than in baselines. Thermal stress resulted in higher NPS, Osm, and G and lower ${\it Cl}$ in serum from female crabs when compared to control females. Holding crabs in laboratory aquaria resulted in short term G elevations over baselines and lower $O \delta m$, $P \pi$ and N P S. The technique of comparing serum constituents of animals

from a given area or experimental treatment to control or baseline values offers promise in developing physiological indices of condition. (This work was supported by the Sea Grant Program.)

SOME PROPLEMS IN THE ISOLATION AND CHARACTERIZA-TION OF ENTYMES FROM SICHENS. E. J. Martin. Math/ Science Div., Ferrum Col., Ferrum, Va. 24088.

The various isolation techniques for lichen enzymes and their problems are discussed with particular emphasis on Parmelia caperata mycobiont invertase. Extraction of this enzyme is difficult due to the resistance of the cells to disruption.

A brief discussion of lichen enzyme purification is followed by a discussion of the problems of localization and characterization of lichen enzymes. The localization is important to the characterization due to the dual nature of lichens. This is particularly evident in the characterization of P. caperata thallus invertase, which may be produced by both symbionts as a co-operative effort. Characterization must be made on partially purified preparations due to the small amount of enzyme available and thus is only tentative.

A COMPARISON OF THE FISHES IN THE CLINCH AND BIG SANDY DRAINAGES IN TAZEWELL COUNTY. VIRGINIA. M. T. Masnik and W. G. Knollenberg*, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va., 24061

Several authors have speculated on a piracy of Clinch River drainage by the Big Sandy in Tazewell County, Virginia. The hypothesis is based on the presence of an interfingering divide and a hydraulic advantage. A preliminary study of the distribution of fishes in both drainages indicates that a piracy did not occur. Geologic evidence for the suspected piracy is lacking. Many headwater taxa found in the adjacent Clinch River system are not present in the upper portions of the Big Sandy. Common headwater forms found in the Clinch River are Campostoma anomalum michauxi, Cottus c. carolinae, Etheostoma simoterum, and Rhinichthys atratulus obtusus while the Big Sandy include Campostoma a. anomalum, Cottus b. bairdi, Etheostoma caeruleum, and Notropis cornutus chrysocephalus. Diversity indices for all collections are presented. Under similar ecological conditions the Clinch River ichthyofauna is more diverse than the Big Sandy.

THE EFFECT OF PERIODIC BURNING ON MARSHLAND INSECT POPULAT-IONS. J. F. Matta and C. L. Clouse*, Department of Biology, Old Dominion University, Norfolk, Virginia.

The deliberate burning of coastal wetlands is a common practice in Virginia even though the ecological effect of this practice is largely unknown. There has been little work done on the effects of burning on the marshland environment and there is no information available on its effect on insect populations.

An analysis of sweep net collections taken at two week intervals between June 26 and September 18, 1972 from six island sites (representing four distinct burning situations) located in the Back Bay National Wildlife refuge indicates that the occurance of the majority of adult forms found on the islands is not significantly affected by the burning, however, the principal herbivore on the islands, [Conocephalus sp. (Fam. Tettigoniidae)] showed significant differences in numbers between the island sites. The mean number per collection ranged from 216 for a site which had not been burned in six years to 42.0 for a site which had been burn-

ed 1 year previously; $\mathbf{S}_{\mathbf{X}} =$ 3.15. Three of the sites, with identical burn histories but radically different plant communities, showed no significant difference in tettigoniid numbers. The means ranged from 4.6 for spikerush community to 14.9 for a mixed stand of cattails, chordgrass and low shrubs.

ENDOCRING RESPONSE OF ACCAMSSIVE AND PASSIVE MICE TO SPACE DEPAIMATION AND INCREASING SOCIAL SCHTACT.
R. McCarty and J. M. Richardson. Dent. of Biology, Old Dominion Univ., Morfolk, Va. 23509

The effects of different housing conditions were observed in aggressive (STM) and passive (STM) male mice (Mus musculus). Experimentation accurred for a two week period following weaning at 24-28 days of age. Adrenal hypertrophy was greatest in CFM males isolated in space deprivation caper. Increases are also reported for CFM males from fixed ropulations of 8 and 16 mice per cage. No significant adrenal weight changes are reported for CFM males. Body weight changes were altered by cage size and population size. Testicular weights were not indicative of endocrine alterations in either strain. The results are discussed in relation to the behavior of the CFM and SFM1 strains and to the endocrine theory of population limitation.

CYTOCHEMICAL ANALYSIS OF ENZYME DISTRIBUTION IN ASCI AND PARAPHYSES OF PODOSPORA ANSERINA. M. Mitchell* and J.E. Perham. Dept. of Biology, Randolph-Macon Woman's Col., Lynchburg, Va. 24504

Perithecia of wild type Podospora anserina were subjected to cytochemical tests for the following enzyme

systems: esterases, acid phosphatase, alkaline phosphatase, cytochrome oxidase, and peroxidase. Distinct sites of enzyme activity were observed in ascogenous hyphae and paraphyses. Age of asci and paraphyses and pH of the reaction mixtures were important factors in the patterns of enzyme distribution.

DIGESTIBILITY OF A HIGH RATION AND A LOW FIBER RATION BY THE GRAY SQUIRREL. S. D. Montgomery*, R. F. Haynes*, J. Hedge* and H. S. Mosby. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Four live-trapped gray squirrels housed in metabolism cages, $16 \times 10 \times 12$ inches, were randomly allotted to two different rations which were similar in nutrients except for crude fiber which was 16% in one ration and 6% in the other ration. A six day preliminary period was used to adjust the squirrels to the cages and to the rations. The squirrels were fed ad libitum and the amount of feed consumed was recorded. A 16 mesh screen was used to separate the feces from the urine. Feces were collected daily and stored in a refrigerator. At the end of the five day collection period the total feces collection was mixed, oven-dried, ground and proximate analysis was performed. Proximate analysis was also performed on samples of the two rations. The percent digestibility was calculated for each

For the two squirrels on the low fiber ration the average percent digestibilities were: crude fiber (34%), crude protein (74%), ether extract (94%), ash (36%), and dry matter (77%). The digestibilities of all nutrients by the squirrels on the high fiber ration were less. The average digestibilities of nutrients for the squirrels on the high fiber ration were: crude fiber (-6%), crude protein (56%), ether extract (63%), ash (14%), and dry matter (37%).

24, 48, AND 96-HOUR LC50 FOR BLUEGILL (LEPOMIS MACROCHIRUS RAF.) EXPOSED TO HEXACHLOROPHENE. E. L. Morgan, R. E. Sparks J. A. Garvin and J. Cairns, Jr., Biology Dept. and Center for Environmental Studies, Va. Polytechnic Inst. and State Univ., Blacksburg, Virginia 24061

Ten bluegill were exposed to each of the following concentrations of hexachlorophene (Sigma Chemical Corp.) in a static 96-hr. bioassay: 1.8, 1.0, 0.56, 0.32, 0.18, and 0.10 mg/l. Hexachlorophene was dissolved in 10 ml certified A.C.S acetone and the volume brought to 17 liters with dechlorinated tap water in glass test jars. There were two control groups: (1) ten fish maintained in dilution water alone and, (2) ten fish maintained in dilution water plus 10 ml acetone. At 0.1 mg/l there was 100% survival after 96 hours. No fish survived after 24 hours in concentrations of 0.56 mg/l and survived after 24 hours in concentrations of 0.56 mg/l and above. In the highest concentration, 1.8 mg/l, all bluegills showed signs of distress within the first hour and were dead within 5 hours. The 24, 48, and 96 hour LC50 (lethal concentration in which 50% of the fish survive for a given time intervals) were 0.29, 0.24, and 0.18 mg/l, respectively. None of the control fish died in the acetone-dilution water

SPECIATION IN A GROUP OF POLYNESIAN LAND SNAILS.

Murray and B. Clarke*. Dept. of Biology, Univ. of Va. and Dept. of Genetics, Univ. of Nottingham, England.

The genus Partula consists of a large number of highly polymorphic species of land snails inhabiting the volcanic islands of Polynesia. Ten members of the genus have been described from Moorea in the Society Islands. The six nominal species of the <u>P. suturalis</u> group form a complex network of relationships characterized by partial

reproductive isolation. In order to assess the evolutionary status of members of the group, random samples of animals from restricted of the group, random samples of animals from restricted areas have been scored for fifty characters and subjected to principal components analysis. The clusters of individuals identified in the several local samples have been compared in a further stage of the analysis. Direct or indirect genetic exchange may be inferred among four of the "species": P. suturalis, P. aurantia, P. olympia, and P. tohiveana. P. mooreana has not yet been included in the analysis. P. dendroica is spatially isolated from the rest but is very similar to, and genetically compatible with, P. suturalis.

The possibility that speciation is occurring in situ is suggested. (Supported by NSF grant GB-26382.)

ASPECTS OF IODINE METABOLISM IN JELLYFISH POLYPS. Olmon* and K. L. Webb. Dept. Environmental Physiology, Va. Inst. Mar. Sci., Gloucester Point, Va. 23062 It has been reported that iodine is required for strobi-

lation in jellyfish polyps, and that it is rapidly lost following a reduction in temperature. Experiments were set up to verify these findings and to determine whether iodine has a role in other metabolic processes in jellyfish polyps. Chrysaora quinquecirrha polyps and podocysts were exposed to a solution containing I-131 for 24 hours. The subsequent rate of loss of radioactive iodine was followed both at a constant temperature of 20 C and after a transfer to 12 C. After an initial loss of radioactive iodine the loss rate remained stable over a period of 2 to 3 weeks. Contrary to previously reported findings, a reduction in temperature had no effect on the loss rate. Polyps which were beginning to form podocysts took up much more iodine than polyps not forming cysts, and the iodine was concentrated in the base region of the polyp at the site of cyst formation. Iodine was also found to be important in strobilation in polyps preconditioned for strobilation by long-term exposure to low temperature. (This work was sup ported by Public Law 89-720, Jellyfish Act.)

A METHOD FOR DETERMINING ECTOPARASITE POPULATION DENSITIES ON GRAY SQUIRRELS. J. C. Parker*, R. B. Holliman*, and M. M. Jones (Sponsor). Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23219, and Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Using a planimeter for determining the areas of flat tracings of skin, the body surface area of 12 adult male and 12 adult female gray squirrels (Sciurus carolinensis) was determined by regiona. The hair was dissolved from the skin using a variation of the Hopkina maceration technique employing a 5 percent solution of aodium hydroxide; a total count of the ectoparasites was made on each region; and the densities of the ectoparasite population on each region were calculated. Eight species of arthropods were found but three apecies of lice were the most abundant. The average population density of all species combined was highest on the back and decreased to legs, head, underparts, and tail, respectively. Neohaematopinus aciuri was present in greatest density on the back; Enderleinellus longicepa occurred in greatest density on the head; and Hoplopleura sciuricola occurred in greatest density on the legs and

This atudy aeeka to demonstrate the feasibility of studying ectoparaaite populations by body regions on small mammals in that the physical position of the parasite is diacloaed, and to provide a unit of comparison between hosta by providing the number of arthropods per unit of skin A SIMULATED MODEL OF A WHITE-FOOTED MOUSE(PEROMYSCUS

A SIMULTIED MODEL OF A WHITE-POORED NOGS (PERMISSON)

LEUCOPUS) POPULATION IN A PART OF THE GREAT DISMAL SWAMP.

J. E. Paschel*, J. H. Richardson and D. E. Sonenshine,

Biology Dept., Old Dominion Univ., Horfolk, Virginia.

A computer model was designed to simulate changes of a
white-footed mouse (Peromyscus leucopus) population in a
peripheral area of the Dismal Swamp. The approach of the simulation is to ask a set of questions about factors that possibly affect Peromyscus leucopus populations, and then to make speculative propositions in answer to the questions. The propositions are stated as logical functions that can be expressed in computer language.

Initially, a number of factors believed to affect small

mammal populations was proposed. Then factors were selected that were believed to affect Peromyscus leucopus populations in the study area. The factors selected for study are the effects of standing water, food availability, nesting site availability and reproduction.

The factors have been expressed as logical functions that affect rates of change within the population, and the functions have been incorporated into a computer program. The simulation will be compared with field data, discrepancies will be identified, and the model will be modified to fit the natural data.

GENETIC CONTROL OF LEUCINE AMINOPEPTIDASE AND ESTERASE ISOZYMES IN THE INTERSPECIFIC CROSS Cucurbita lundelliana x C. moschata. B. G. Pinto and J. R. Wall, Dept. of Biology, George Mason Univ., Fairfax, Va. 22030.

In a continuing study of the origins and evolutionary re-

lationships of the species of the New World gemus Cucurbita, horizontal starch gel analyses of seed extracts of C. lundelliana, C. moschata cv. Long Genoa Queen, their F₁ and F₂, and three of the four possible interspecific backcrosses reveal that these two species differ by codominant alleles for alpha-naphthyl acetate esterase (Est) and leucine aminopeptidase (LAP). C. lundelliana, also known as the Peten Gourd, segregates for two alleles determining slow and slow' Gourd, segregates for two alleles determining slow and slow' Est isozymes and is homozygous for the LAP locus, having a slow LAP phenotype. C. moschata is homozygous and monomorphic for Est (fast) and LAP (fast). The F, C. lundelliana (Est slow, LAF slow) x C. moschata, Is fast/slow for both isozyme systems. The F, Est ratio gives a satisfactory fit to a 1:2:1 ratio (.50> P>.30); the F, LAP ratio reveals a significant deviation from expected (.05> P>.01). Three of the four possible reciprocal interspecific backcrosses when analyzed for both enzyme systems give a satisfactory fit to the expected 1:1 ratio in five instances, in the sixth instance the data are inconclusive.

THE EFFECT OF CHRONIC EXPOSURE OF Calcium Cyclamate ON Meriones unguiculatus. A. E. Pyles and G. C. Llewellyn, Dept. of Biology, Va. Commonwealth Univ. and C. E. O'Rear and F. W. Rea, Va. Dept. of Agriculture and Commerce,

Richmond, Va. 23220 The effect of chronic administration of calcium cyclamate in Mongolian gerbils, Meriones unguiculatus, was investi-gated. Calcium cyclamate in aqueous solution was administered as the only liquid to weanling test gerbils of both sexes over a period of approximately five months. There were no fatalities in either the experimental or control animals. An increase in gain in body weight of experimental over control animals was recorded. As adults, weights in control and experimental groups were comparable within a few grams. Significantly larger amounts of water were consumed by experimental animals throughout the experiment. Urine analysis conducted included pH, protein, glucose, ketones, urine bilirubin and blood. Histologically, no tumors were observed on careful macroscopic and microscopic examination of the urinary bladder, liver or kidneys at necropsy. Neither was precarcinogenic activity observed.

A STUDY OF THE POSSIBLE EFFECTS OF VARIOUS DRUGS AS M. Stort of the Fossial Bristols of Wildows And Story of Bridge Roll Bristogators of A Fright Reaction in Fish. J. R. Reed, W. Wieland, and T. D. Kimbrough. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

Two cyprinid fishes, Clinostomus funduloides and Notropis cornutus were tested with naturally occurring

substances including some well-known biogenic amines. Behavioral responses to histamine were similar to those observed in previous tests with natural alarm substance extracts. A response threshold was obtained at 0.01 ppm. Spectrophotofluorometric emission spectra also indicated that the natural alarm substance known to exist in many species of fish may be a ringed or double ringed compound similar to a purine.

FOOD HOARDING IN FREELY GROWING LABORATORY POPULATIONS OF PRAIRIE DEERMICE (Peromyscus maniculatus bairdii). L. Z.Rice* and C. R. Terman. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185.

The purpose of this investigation was to study food hoard-

ing behavior in three freely growing laboratory populations of prairie deermice.

Proximity of the nestbox to the feeder, the hoarding animal, and the presence of pellets in the feeder were important in maintaining hoarding activity and determining hoard loca-

Both male and female (parous and nulliparous) mice hoarded. These mice rarely initiated aggressive activity and the hoard was never defended. Food pellets only were hoarded and not wooden pellets, cotton balls, or young.

The presence of pellets in a particular nestbox acted as a

cue directing hoarding activity. During early tests when pellets alone were removed from the original hoard site, disruption of hoarding occurred in two of the three populations. Later tests involving removal of (1) both hoarder and food pellets and (2) only pellets resulted in hoarding disruption in all populations.

No evidence was obtained in this study that hoarding causes cessation of population growth. It appears, however, to result in spatial organization of the population with respect to the hoard and location of food consumption. This may, along with other factors, influence cessation of growth in populations. Supported by NIH-HD-04787

VARIATIONS IN <u>CEPAEA NEMORALIS</u> IN LYNCHBURG, VA. A. V. Richards*. Dept. of Biology, Univ. of Va., Charlottesville, Va. 22903

Samples of <u>Cepaea nemoralis</u> have been collected in Lynchburg from 56 localities, of which 26 have provided samples of sufficient size for analysis. The Lynchburg colonies are apparently monomorphic with respect to yellow shell color. There is a positive association between shady habitats and high frequencies of band fusions and also between the proportions of top and bottom fusions regardless of vegetational category. An analysis of the differences in the proportions of unbandeds in neigh-boring colonies shows significant variation in areas where habitat vegetation differs. There are significant differences between the proportions of unbandeds in colonies grouped into four vegetational categories. These nles grouped into four vegetational categories. Mese characteristic associations are further evidence of visual selection as reported by Cain and Sheppard (1954). Cepaea nemoralis in Lynchburg achieves crypsis in dark even habitats in the same manner as C. hortensis, effecting an overall darkening of the shell by the increasing fusion of bands. The data suggest that there may be a departure from the equal proportions of adult and young unbandeds which one would expect in the absence of selection. A model for two kinds of selection operating at different times in the life cycle is proposed.

INSECTS ASSOCIATED WITH THE THERMAL WATERS OF WARM SPRINGS RUN, VA. <u>William H Robinson</u>*. Dept. of Entomology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

There is a small community of insects inhabiting the thermal waters (35°C) of Warm Springs Run. The habitat has been sampled during all seasons. Some of the insects include representatives of the orders: Hemiptera, Coleoptera, Odonata, Ephemeroptera, Plecoptera, and Diptera. SOME PRELIMINARY HISTOLOGICAL OBSERVATIONS OF THE HINDGUT OF PROCAMBARUS ACUTUS ACUTUS GIRARD. S. J. S. Roman* and D. J. Peters. Dept. of Biol., Christopher Newport Col., Newport News, Va. 23606

The hindgut of Procambarus acutus acutus Girard passes from the midgut along the dorsal surface of the liver; into the abdomen between the dorsal and ventral muscle bundles and terminates on the ventral surface of the telson. The gut is lined with tall columnar epithelial cells that appear to be apocrine. These cells rest upon a thin basement membrane and their free surface is covered with a laminated cuticle. The latter is thickest in the anal region and thinnest at the midgut-hindgut junction. Several layers of smooth muscle form what appears to be a sphincter muscle at the previously mentioned junction. Under the epithelium, scattered muscular elements, cushion cells and connective tissue form the submucosal layer. Irregularly arranged muscle bands diverge from the longitudinal muscles and are attached to the epithelial layer. This arrangement may govern the diameter of the gut lumen. The entire hindgut is encased in circular muscle.

USE OF CHROMIC OXIDE FOR ESTIMATION FECAL OUTPUT IN WHITE-TAILED DEER AND SHEEP. O. T. Sanders*, J. E. Skeen* and C. Faulds* and Dr. H. S. Mosby (Sponsor). Div. of Forestry and Wildlife Sciences, Va. Polytechnic Institute and State

Univ., Blacksburg, Va.

Most procedures for measurement of forage consumption

requires determination of fecal output. External indicators such as chromic oxide (Cr_2O_3) have been successfully used in domestic species. The purpose of this study was (1) to evaluate the Cr_2O_3 method as an estimator of fecal output in white-tailed deer (<u>Odocoileus virginianus</u>), (2) to determine appropriate sampling times and (3) to compare the accuracy obtained with deer to that of sheep (Ovis aries). Two yearling bucks and two yearling wethers, all on the same ad libitum diet, were administered 3.0 g of Cr₂O₃ daily for 10 days. After a 5 day equilibration period fecal samples were collected twice daily (0800 and 1600 hrs.) over a 5 day sampling period. Total feces were also collected for the 5 day period. Results indicate that an accurate estimate of fecal output is obtained for both days and the samples are realled. both deer and sheep only when daily samples are pooled over several days. Pooled evening samples yielded better estimates of fecal output in deer than the pooled morning samples. In contrast differences between morning and evening estimates were small for the sheep. The Cr₂O₃ technique was as accurate in estimating fecal output in the deer (109 and 103 percent of actual) as for the sheep (95 and 99 percent of actual).

FETAL SEX RATIOS IN CATTLE AND SHEEP. Patrick F. Scanlon. Div. of Forestry and Wildlife Sciences, V.P.I.&S.U., Blacksurg, Va. 24061

Theoretically the sex ratio in animals should approach equality unless factors other than chance interferes with fertilization. Some reports have indicated that a preponderance of males occurs during gestation and that differential mortality occurs in utero. Also, reports have indicated that in Bovidae, a tendency exists for a greater preponderance of males in the left uterine horn. The sex ratio of 586 cattle fetuses and 1392 sheep fetuses was examined as was the sex ratios at birth of 2315 calves and 1151 lambs. Overall sex ratio of cattle fetuses was 51.2% males and of sheep fetuses was 50.0% males. Sex ratio at birth of calves and lambs was 53.3% males and 49.8% males respectively. Percent males in left and right uterine horns in cattle were 50.8 and 51.4 respectively and for sheep were 52.7 and 47.8 respectively. The difference in sex ratios within uterine horns in both species were nonsignificant.

A LAPAROTOMY TECHNIQUE FOR USE WITH WHITE-TAILED DEER.

A LAPARCHOMY LECHNIQUE FOR USE WITH WHITE-HALLED DEEK.

Patrick F. Scanlon and David K. Lenker*. Div. of Forestry and Wildlife Sciences, V.P.I.&S.U., Blacksburg, Va. 24061

A technique for laparotomy would permit examination of female genitalia without sacrifice of the animal. Observations of ovarian activity, pregnancy diagnosis, egg transfer, ovariectomy and caesarian section are facilitated by the availability of such a technique. A restraining and support apparatus has been developed to facilitate most but of the apparatus has been developed to facilitate restraint of the white-tailed doe during surgery. When the doe is restrained in this apparatus, the surgical site is conveniently in this apparatus, the surgical site is conveniently exposed. The laparotomy technique follows. A mid-ventral incision, about 5 mm in length, is made just anterior to the udder. The reproductive organs are located by inserting two fingers through the incision. The tip of the uterine horn is grasped between the fingers and drawn towards the incision. The ovaries, Fallopian tubes and uterus may be exposed through the incision in a popular animal. The exposed through the incision in a nonpregnant animal. incision is closed using three discontinuous sutures through the body wall. The laparotomy may be conducted using local or full anaesthesia and has been conducted successfully under field conditions.

ASPECTS OF EARLY PREGNANCY IN WHITE-TAILED DEER. Patrick F. Scanlon, W. F. Murphy, Jr. * and D. F. Urbston *. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061. Reproductive organs were recovered from 34 pregnant white-

tailed deer harvested during legal hunts in Aiken and Barnwell Counties, South Carolina (December 8-11, 1971). Mean ovulation rate was 1.98 (Range 1-3). Pre-implantation loss of embryos in 29 double-ovulating does was 6.9 percent and in 2 triple-ovulating does was 50.0 percent. One of three embryos in single-ovulating does had undergone transuterine migration to the uterine horn opposite the side of ovulation. When two ovulations occurred from one ovary and both embryos survived, transuterine migration of one embryo was observed in all 15 specimens observed. Sixteen does were lactating at the time of recovery. This indicates that estrus, ovulation and pregnancy initiation can occur while the doe is lactating. The mean stage of gestation of lactating does was comparable to that of non-lactating does (45.5 days pregnant vs 46.8 days pregnant). Fetal membranes in twin-pregnant does were fused in 17 of 24 specimens. The number of maternal cotyledons invaded ranged from five to 12. The model value was six.

THE OCCURRENCE OF AFLATOXIN IN SAMPLES OF PEANUTS FROM VIRGINIA. R. A. Scheele, G. C. Llewellyn, Dept. of Biology, Va. Commonwealth Univ. and C. E. O'Rear and T. Eadie, Va. Dept. of Agriculture and Commerce, Richmond, Va. 23220

Data concerning the percent of shell peanuts containing aflatoxin in Virginia as tested by the mycotoxin laboratory, VDAC, was utilized to realize the recent rise in aflatoxin in Virginia peanuts. Evaluations were made by incorporin Virginia peanuts. Evaluations were made by incorporating the different types of aflatoxins (B₁, B₂, G₁, G₂) as a complete entity on a monthly basis. Climatological data for Virginia as compiled by the U.S. Dept. of Commerce and Environmental Data Service was utilized to recognize the monthly patterns of precipitation, temperature and evaporation for the period Sept. 1964 to Jan. 1972 in the Suffolk, Virginia area. Attempts were then made to compare monthly climatological deviations with the percent of shelled peanuts containing aflatoxin. shelled peanuts containing aflatoxin.

Correlations between climate and aflatoxin production revealed that for the period, 1964 to 1971, the percentage of aflatoxin found tends to assume two peaks for each year. These peaks are nearly constant for this period in that December and June are the predominating peak months. Aflatoxin levels tend to correlate directly to conducive temperature range for aflatoxin production. The highest peaked month for aflatoxin levels is preceded by a monthly temperature within the conducive range. It was also noted that 84% of the time above average rainfall will increase

aflatoxin content in tested peanuts.

EFFECT OF FLUCTUATING RESERVOIR DISCHARGE ON PHYTOPLANKTON POPULATIONS IN CLAYTOR LAKE, VIRGINIA. T. L. Schulte*, and R. T. Lackey*. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

In the past it has been theorized that high lake turnover time during certain periods of the year may limit phytoplankton production. With the recent, and apparent successful, introduction of a forage-feeding fish, the landlocked alewife (Alosa pseudoharengus), this possible loss of primary production has become a concern of fisheries scientists. The possible effects of fluctating reservoir discharge on reservoir phytoplankton standing crop, productivity, and qualitative composition is reported. In addition, the relationship of the amount and kinds of phytoplankton discharged from Claytor Lake in relation to the rate of discharge and amount and kinds of phytoplankton in the reservoir is discussed.

A COMPARISON OF THE OCCURRENCE OF OVARIAN TUMORS AND RELATED BODY ORGANS IN TWO COLONIES OF <u>Meriones unguiculatus</u>. C. A. <u>Sledd</u> and G. C. Llewellyn, Dept. of Biology, Va. Commonwealth Univ. and C. E. O'Rear and F. W. Rea, Va. Dept. of Agriculture and Commerce, Richmond, Va. 23220

The organs and tissues from adult Mongolian gerbils of both sexes from two colonies were studied. Colony P consisted of 92 animals and was obtained from a commercial source, while Colony L consisted of a random sample of 43 animals taken from our highly inbred Laboratory Colony.

At necropsy, female animals were examined macroscopically for ovarian cysts. Ovarian cysts ranged up to 1 cm in diameter and occurred in Colony P and L at 12% and 20% levels respectively. In all animals the liver and spleen color variations were recorded. Adrenal size was noted. Weights determined included that of the kidneys, liver, spleen, testes and total body weight. Muscle tissue from

the thigh regions were analyzed for fat and crude protein.

All animals from both colonies having ovarian cysts were always below average in body weight, liver weight, kidney weight and adrenal size.

MASS REARING OF RADIOISOTOPE-TAGGED LARVAL TICKS FOR ECOLOGICAL INVESTIGATIONS Laniel E. Sonenshine, Dep't. of Biology, Old Dominion University, Norfolk, Va. 23508.

Mass rearing of radiolabelled larval ticks for use in field studies is described. Mass rearing was done with the American dog tick, Dermacentor variabilis (Say); the lone star tick, Amblyomma americanum (L.); and the Rocky Mountain wood tick, D. andersoni Stiles; small numbers of tagged larvae of the rabbit tick, Haemaphysalis leporispalustris (Packard), also were reared. Inoculation of 14c glucose into engorged, procreant females of these 4 species was done to provide sufficient suitably tagged larvae to meet the needs of field programs, ranging from only a few thousand in 1 species to approximately 250,000 per year in another species. Large yields were obtained, although less than predicted in previous published studies. Responsibility for the reduced yield was attributed, primarily, to decreases in transtadial transmission efficiency (eggs to larvae) and percent hatching, both of which were less than expected. Nevertheless, the planned overproduction of tagged larvae compensated for these reductions in yield (except in 1 instance). The program was found to be practical both in yield and economics.

 1 This study was supported by contract AT-(40-1)-3514 with the Division of Biology and Medicine, U. S. Atomic Energy Commission, Washington, D. C.

ECOLOGICAL FACTORS AFFECTING THE SURVIVAL OF TWO SPECIES OF TICKS IN THE GREAT DISMAL SWAMP. <u>Daniel</u> E. <u>Sonenshine</u> and Mary Keith Garrett*. Dept. of Biology, Old <u>Dominion Univ</u>., Norfolk, Virginia. 23508

The relative abundance of the lone star tick, Amblyomma americanum and the American dog tick, Dermacentor variabilis was determined by roadside flagging of a 25 mile section of the Great Dismal Swamp. A significant difference was observed: the dog tick appears to be well established, though density estimates suggest its abundance is low; the lone star tick apparently is not established in the area.

Preliminary surveys of host populations and abiotic factors were conducted in an effort to explain the limited abundance of the two species of ticks. The observed presence of small mammals and raccoons suggests that a host support system for the dog tick is present, though the abundance and distribution of this support system are unknown. Deer and other large mammals which are among the most important hosts of the lone star tick were rarely observed. We doubt that an adequate host support system exists for this species of tick.

Variations in atmospheric moisture deficit were found to be within reported survival ranges of these ticks. Observed light intensities within the forest were only 10% of that observed in the adjacent exposed fields; this may affect the degree of activity of these ticks. Up to 60% of a study site within the forest was flooded for 11 consecutive weeks. This inundation is believed to be a dominant factor which limits the survival of introduced ticks in the Swamp.

Heat Seeking Activity and Thyroid Development in Hatchling Japanese Quail (Coturnix c. japonica). D. E. Spiers, R. A. McNabb, and F. M. A. McNabb, Department of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Heat seeking behavior of hatchling Japanese quail was examined by two different techniques. In one experiment, groups of quail chicks (3-4 individuals) were exposed to a temperature gradient (28-44°C), produced by an infra-red heat lamp. The body temperature of each bird was determined at different times during the day, starting 2 days after hatching. On day 2, the body temperature averaged $40.5\,^{\circ}\text{C}$ and rose steadily, reaching about 42.5°C on day 16. This is 0.5°C higher than adults. In the second experiment, individual birds were placed in a cage containing a photoelectric relay system. The bird turned on a heat lamp by interrupting a small beam of white light. At 2-3 days of age, the chicks kept the lamp on 30 to 24% of the time. By 16 days of age, chicks kept the lamp on only 14% of the time. The results of both experiments indicate that body temperature increases and heat demands decrease after hatching. Histologically, the thyroid gland showed a decreasing follicle cell height for 5 days after hatching. After this time there was an increase in follicle cell height from 1.5_μ up to the adult size (4.25_μ) at approximately day 14. (This study was aided by a grant from the Frank M. Chapman Memorial Fund, American Museum of Natural History).

AN EXPERIMENTAL STUDY OF MOVEMENT IN NATURAL POPULATIONS OF THREE SPECIES OF RODENTS. P. P. Staples*, and C. R. Terman. Dept. of Biology, College of William and Mary, Williamsburg, Va., 23185
Four experimental manipulations, each consisting of a re-

Four experimental manipulations, each consisting of a removal and return phase, were performed to investigate the invasion-during-removal and movements-after-release of three species: Mus musculus, Microtus pinetorum, and Microtus pennsylvanicus. There was a significantly greater movement of Mus into the experimental than the control area during the removal period, suggesting that the invasion was not due to random movement. There was no difference between the two plots in regard to the invasion of M. pinetorum or M. pennsylvanicus during this same interval.

During the period following the release of the removed animals into the field, new <u>Mus</u> and <u>M. pinetorum</u> animals appeared to move more than resident animals. Comparisons between new and resident, young and adult, male and female, and experimental and control animals of all species showed variable results. The different species also varied in their degree of responsiveness. Their responses, however, did appear to correlate with the known ecological characteristics of the different species populations. (Supported by NIH-HD-04787)

THE EFFECTS OF EXPERIMENTALLY-VARIED LEVELS OF SEROTONIN ON HEMOGLOBIN MEASUREMENTS IN MICE. J. Steiner and T. D. Kimbrough. Dept. of Biology, Va. Commonwealth Univ., Richmond, Va. 23220

Varying the levels of serotonin in male and female

Varying the levels of serotonin in male and female Swiss Webster mice by intraperitoneal injections of serotonin and of two serotonin inhibitors, reserpine and p-chlorophenylalamine altered the levels of hemoglobin. The hemoglobin concentration was measured for each sample of blood with a spectrophotometer (Spectronic-20). Wave length was set at 545 millimicrons. It was found that females consistently had a slightly higher hemoglobin concentration than males, that both serotonin and the inhibitors lowered hemoglobin concentrations, and that serotonin acting alone apparently caused a moderate decrease in hemoglobin concentration at 1 hour post-injection, a marked decrease at 2 hours post-injection and a moderate increase at 3 hours post-injection. It was further observed that reserpine treatment caused a consistent increase in hemoglobin concentration during the 3 hour post-injection period while p-chlorophenylalamine treatment caused a moderate decrease at 1 hour post-injection, a marked increase at 2 hours post-injection and a slight decrease at 3 hours post-injection and a slight decrease at 3 hours post-injection

CORRELATION OF HAEMOLYMPH PROTEIN SYNTHESIS WITH PROTEIN INCORPORATION INTO THE COCKROACH CUTICLE. E. A. Stielstra and R. R. Mills. Biology Dept., Va. Commonwealth Univ., Richmond, Va. 23220

After the American cockroach, <u>Periplaneta americana</u> (L.), molts, the soft, white, new cuticle both hardens and darkens. Protein is synthesized at this time in various organs and is transported via the haemolymph to the integument. Radioactive analysis of haemolymph and cuticle proteins after the injection of carbon-l¹ leucine suggests that blood proteins are incorporated into the cuticle relatively unchanged. Further work using labeled blood proteins from one animal and injected into another supports this contention.

REPRODUCTIVE ATTRIBUTES OF PRAIRIE DEERMICE RELATED TO MECHANISMS OF POPULATION CONTROL. C. R. Terman. Biology Department, College of William and Mary, Williamsburg, Va., 23185

The growth of laboratory populations of prairie deermice was regulated at widely different numerical levels in the presence of surplus food and water and under identical conditions of the physical environment. Control of growth was achieved by either cessation of reproduction or failure of young to survive. In this study 94% of the females born into the populations and reaching at least 90 days of age failed to reproduce. The weights of the reproductive organs of males and females from these populations were significantly smaller than those of bisexual pair controls. Histological analysis of the ovaries revealed that populations had significantly more atretic follicles and significantly smaller graafian follicles of maximum size than controls.

The mechanisms by which population growth was controlled

The mechanisms by which population growth was controlled were reflected in the histological characteristics of the ovaries and the weights of the reproductive organs of both males and females. Offspring born into populations in which growth was controlled by cessation of reproduction exhibited a significantly smaller percentage of ovulations and significantly smaller ovaries, uteri, testes, vesicular glands, and bacula than those in populations whose growth was regulated by mortality of young. The significance of these findings to mechanisms of growth regulation and attributes of individual populations is discussed.(Career Dev. Award NIH-HD-04787)

THE USE OF COMPUTERS TO TEACH FISHERIES SCIENCE. Franklin B. Titlow and Robert T. Lackey*. Div. of Forestry and Wildlife Sciences, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Fishing pressure on America's recreational fisheries will increase substantially in the future. Effective management of recreational fisheries is a prerequisite to even begin to successfully cope with increased demands. Effective fisheries management is based, to a large extent, on field experience, combined with a solid education in fisheries principles. Providing managerial experience to fisheries science students at the graduate and undergraduate levels presents a problem to educators. Developing management educational programs under field situations is not feasible for more than a few students. Computer-implemented teaching games allow students to devise and apply management programs during classroom lab periods. Immediate results of their managerial decisions are made possibly by "playing the games" with the aid of computer programs. Teaching games are based on existing aquatic ecosystems. A game is developed to mimic recorded responses of the ecosystem on which it is based as closely as possible, thus creating a realistic management situation.

EFFECT OF HIGH OXYGEN LEVELS ON MARINE INVERTEBRATES. J. J. Torres and C. P. Mangum, Dept. of Biology, $\overline{\text{Col. of William}}$ and Mary, Williamsburg, Va. 23185

Previous investigations dealing with oxygen poisoning in aquatic metazoa have been scant, and chiefly limited to fresh water infauna. H. M. Fox discovered in 1954 that oxygen levels equal to and exceeding air saturation had deleterious effects on animals found normally in oxygen deficient water. Corroborative evidence has been slight and chiefly restricted to animals previously investigated by Fox. Due to the dearth of evidence regarding the effects of hyperoxia on marine organisms, the subject has been reopened for investigation.

Eleven species of marine invertebrates representing both infaunal and epifaunal forms were exposed to oxygen concentrations of ca. 300% air saturation for a minimum period of 7 days. Of these eleven species only two exhibited a negative response to hyperbaric oxygen. The anthozoan Haliplanella luciae showed 100% mortality; and the polyp form of the scyphyzoan Aurelia auritia exhibited impaired setting ability.

EFFECTS OF SEROTONIN AND CYCLIC AMP ON THE DARKENING OF THE COCKROACH CUTICLE. R. D. VandenBerg and R. R. Mills. Biology Dept., Va. Commonwealth Univ., Richmond, Va. 23220

Previous investigations have shown that newly molted American cockroaches, <u>Periplaneta americana</u> (L.), release a tanning hormone (known as bursicon) from the terminal abdominal ganglion. In addition, if the animal is ligated at the waist immediately after shedding the old cuticle, the head and thorax remain white. The injection of serotonin into the white thorax has little if any effect on the tanning process and does not increase the incorporation of carbon-l¹ tyrosine into the cuticle. On the other hand, if dibutrylcyclic AMP is injected into the ligated white thorax, the tanning process is potentiated and additional carbon-l¹ tyrosine is incorporated into the cuticle. The cyclic AMP also increases the uptake of l¹C-tyrosine by blood cells and from these data it is speculated that the tanning hormone may activate membrane adenylate cyclase.

NITROGEN COMPONENTS IN URINE OF THE MALE DOMESTIC FOWL (GALLUS DOMESTICUS). J. M. Ward, Jr.*, R. A. McNabb and F. M. A. McNabb*. Department of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Urine was collected from roosters fed high and low pro-

Urine was collected from roosters fed high and low protein diets (33% protein and 11% protein, respectively) and provided with water ad libitum. Replicate urine samples were taken simultaneously and centrifuged. Precipitated uric acid and supernatant urine were separated and frozen for storage. Replicates were analyzed for uric acid and ammonia in both liquid and precipitated urine fractions.

Roosters on the low protein diet excreted ammonia at a rate four times that of roosters on the high protein diet.

This is contrary to results found in pigeons.

A comparison of the ratio of ammonia to uric acid in the supernatant and precipitate urine fractions revealed that ammonia was present primarily in the supernatant, whereas, uric acid was localized in the precipitate.

As the concentration of total uric acid (precipitate and supernatant) increased, the concentration of total ammonia increased initially and then decreased at higher uric acid concentrations. (Supported by NIH Grant AM14991.

NITROGEN CYCLING IN ANTARCTIC FRESH-WATER ECOSYSTEMS.

E.B. Wodehouse*, and B.C. Parker. Dept. of Biology, Va.

Polytechnic Inst. and State Univ., Blacksburg, Va. 24060.

During the austral summer of 1970-1971, nitrogen cycling was studied in two meltwater lake basins in the vicinity of Palmer Station, Anverse Island, Antarctica (64° 46'S, 60° 05'W). The larger and deeper of the two lakes (located on Norsel Point) was oligotrophic and supported a relatively small algal population. The smaller and shallower lake (located on Humble Island) was eurrophic and supported luxuriant algal growth. An Adelie penguin rookery just outside the Humble Island lake basin was the major source of nutrient enrichment for the island lake.

Within each lake basin, the movement of nitrogen as ammonia, nitrate and nitrite was sampled. These nitrogen sources were measured in rain, snow and glacial meltwater for each lake. Special attention was given to the sampling of ammonia evolved from the penguin rookery and transported through the air. From 1 to 15 mg per sq m per day of ammonium nitrogen (N) was collected in glacial meltwater traps situated along the Humble Island lake while less than 1 mg per sq m per day was collected at sites along the Norsel Point lake. These results help to illustrate that airborne ammonia can play an important part in the nutrient enrichment of fresh-water lakes and must be considered in any evaluation of nitrogen cycling. (Aided by NSF grant GA - 16768)

Section of Botany

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

EFFECT OF ACUTE GAMMA IRRADIATION ON THE INCIDENCE OF TUMOR-LIKE STRUCTURES AND ADVENTITIOUS ROOTS IN LETTUCE PLANTS. <u>David A. Bankes</u>, Dept. of Biology, Christopher Newport Col., Newport News, Va. 23606

Acute y-irradiation caused tumor-like structures and an increase in the incidence of adventitious roots on (Lactuca sativa H V great lakes). While untreated plants of this variety only occasionally develop adventitious roots on stems, the number of plants with adventitious roots increased after exposures of 4 and 6 kR and reached 100 per cent after 7 kR. Similarly, the number of advenroots per plant increased with exposure dose. Some roots formed directly on the stems, but they occurred more frequently on small (1-5 mm diam) bulbous, nonchlorophyllous tumors which developed on leaves as well as on stems. Larger (up to 30 mm diam) chlorophyllous tumors formed after exposures of 6 and 7 kR. They were associated with basal leaves, being most common at the bascs of the blades. In some cases they occurred along the leaf margins. Of the plants exposed to 6 kR, 80 per cent became tumorous whereas only 50 per cent of those exposed to 7 kR formed tumors.

A PRELIMINARY LOOK AT THE GENUS MELANTHIUM L. Norlyn L. Bodkin, Dept. of Biology, Madison College, Harrisonburg, Va. 22801 and Dept. of Botany, Univ. of Md., College Park, Md. 20742.

Melanthium is a small North American genus with at least one of the species occuring from Connecticut to Minesota to Texas and east to northern Florida. The plants grow in a wide range of ecological niches from bogs to praries.

There is considerable variation in the taxonomic opinion in the genus <u>Melanthium</u> L. as to the number of species in the genus, the status of the genus itself and the taxonomic characters used in this determination. In Species Plantarum, 1753, Linnaeus described the first two species of the genus, M. virginicum and M. sibiricum. Since that time an additional 75 species have been recognized, only five since 1885. Current floras and manuals now include only two to four species. One of the Linnaean species, $\underline{\text{M. sibiricum}}$, is included in $\underline{\text{Zygadenus}}$ Michx. Considerable intergeneric and infrageneric transfer has occured in the history of Melanthium. Of the more common North American taxa to which transfer has been made 23 of the 77 described species have been placed in synonomy either within Melanthium, Veratrum The most severe treatment of the genus was or <u>Zygadenus</u>. its complete dismantling with all species being placed in <u>Veratrum</u>. Thus, in the taxonomic history of <u>Melanthium</u> the number of species recognized in the judgements of the taxonomists varies from 77 to none.

HEPATICOLOGY IN VIRGINIA. $\underline{\text{p.a.}}$ Breil. Dept. of Natural Sciences, Longwood Col., Farmville, $\overline{\text{Va}}$. 23901

Liverworts have been sporadically collected in Virginia since the mid 19th century. Most collections have been few in number primarily because the collectors were more interested in vascular plants. During the last 50 years, several bryologists including Paul Patterson, Rudolf Schuster, Aaron Sharp, H. Iltis, Irma Schnooberger, and Frances Wynne have added substantially to our present knowledge of the numbers and distribution of Hepaticae in the state. Nonetheless the majority of collections have been made in the mountainous part of the state or the coastal plain with almost none from the southern piedmont. The present number of known Hepaticae from these regions is approximately 140 species, of which 3/4ths are leafy and the remainder thallose.

In the past two years the author has collected liverworts in five counties of the southern piedmont of Virginia. To date, 40 different liverworts have been identified and the area has hardly been scratched.

COMPARATIVE ROOT UPTAKE AND TRANSLOCATION OF FOUR 14c-LABELED NONIONIC SURFACTANTS FROM NUTRIENT SOLUTION BY CLYCINE MAX L. E. R. Butts* and C. L. Foy, Dept. Plant
Path. & Physiol., Va. Poly. Inst. & State Univ., Blacksburg, Va. 24061

Eight to 12-day-old soybean plants were allowed to adsorb fatty acid (FA) or polyoxyethylene (POE) $^{14}\mathrm{C}$ -labeled nonionic surfactants Tween 20 (FA or POE), Tween 80 (FA or POE), Span 20 (FA) and Span 80 (FA) from 1/2 strength Hoag-land's nutrient solution for 1 to 7 days. The plants were mounted, oven-dried, pressed and exposed to X-ray film for 2 weeks. The distribution of $^{14}\mathrm{C}$ was determined by autoradiography and counting. Aliquots of the treatment solutions were also radioassayed at each harvest and the progressive removal of ¹⁴C was plotted.

For all treatments, small quantities of 14°C were translocated to soybean shoots increasingly with uptake time and concurrently with the diminution of $^{14}\mathrm{C}$ in the treatment solution. Relatively more $^{14}\mathrm{C}$ was retained by the roots than was transported to the shoots. Root uptake of 14C was reduced as the surfactant concentration in the ambient solution was increased from 0.003% through 1.0%.

FA label from both Tween and Span surfactants was more readily absorbed and translocated than POE labeled Tween compounds. Mobility and accumulation patterns of the POE label were characteristic of substances which move only in the apoplast, whereas the FA label appeared to be phloem mobile also. (Aided by USDA Grant No. 12-14-100-9211[34]).

THE FLORA OF THE HEADWATERS OF CORNELIUS CREEK, BOTETOURT COUNTY, VIRGINIA. T. H. Dalmas. Dept. of Natural Sciences, Longwood Col., Farmville, Va. 23901 The headwaters of Cornelius Creek support a rich flora

characteristic of seepage areas at high altitudes on north facing slopes of the central Virginia Blue Ridge Mountains. In the two acres studied, three ecological habitats were encountered; a dry forested tract, a wet forested tract, and an open glade. Some of the species of vascular plants which are present are representative of a more northern flora. One hundred and twenty vascular plants and twenty-five bryophytes were collected and deposited in the herb aria at the Peaks of Otter and Longwood College.

RCOT-HAIR DIFFERENTIATION IN <u>ELODEA</u>. <u>Larry W.</u>
<u>Dosier*</u> and J. L. Riopel. Dept. of Biology,
Univ. of Va., Charlottesville, Va. 22901
Differences in the growth and differentiation
processes of trichoblasts and their sister epidermal cells were examined in the root of <u>Elodea</u> canadensis. Roots showing near uniform initiation of hairs were selected from field collected roots and cell, nuclear, and nucleolar dimensions determined from prepared sections. The Feulgen technique was employed with photometry for determination of DNA content in other sections.

Cell length accounts for most of the differcell length accounts for most of the differential volume during development. No discontinuity in the rate of growth is evident. Nucleolar and nuclear diameters are greater from the point of formation. Preliminary results indicate DNA is of the same level of magnitude in both types of cells. Results are discussed in relation to recent studies of trichoblasts.

NOTES ON ARCTIC AND SUBARCTIC BASIOIOMYCETES. D. F. Farr* and O. K. Miller, Jr. Dept. of Biology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The species herein reported are Homobasidiomycetes

typically found in tundra plant communities. The genus Omphalina has three species which form a symbiotic association with the green algae Coccomyxa, Omphalina luteovitellina (Pilat and Nannf.) M. Lange, O. ericetorum (Fr.) M. Lange, and O. hudsoniana (Jenn.) Bigelow. These basidiolichens have a characteristic arctic alpine distribution. The taxonomy of these three species in Alaska is discussed with special reference to (a) the amyloid reaction of some cell walls in the pileus and gill trama, a new characteristic reported for the first time in this genus, and (b) host ranges. Species of the genus Laccaria also are well represented in the Alaskan flora. However, placement of these specimens in known species has proven difficult, and the reasons for this difficulty are considered. Coprinus martinii Favre ex Orton is reported for the first time from North America.

SOME STUDIES ON THE CULTIVATED PLANTS SURVIVING ON THE ABAN-DONED HOMESITES IN THE SHENANDOAH NATIONAL PARK. J. Elwood Fisher. 22801. Dept. of Biology, Madison Col., Harrisonburg, Va.

The abandoned homesites in the Shenandoah National Park have been undergoing an undisturbed succession ranging from thirty to forty years. The inhabitants left behind numerous varieties of cultivated and ornamental plant species. Some of these have died or are dying, other survive but are severely crowded, while a few are effectively competing with native species.

Most homesites had many fruit trees, but the apple is the only species with frequent seedlings. The wineberry was a popular raspberry and is well established at nearly every site.

A surprisingly large number of ornamental remain. Daylilies, daffodils, and irises are the most common perennial bulbs, but several others have been recorded. Japanese honeysuckle and periwinkle are the only ornamental vines found so far. Several popular shrubs have been noted, Virginia pine, black locust, and the tree of heaven are

the most frequent invader in old field succession in the

Some interesting interviews have been made with former residents of the area.

HOST RANGE STUDIES OF ENDOGONE GIGANTEA. J. A. Fox* and L. Spasoff. Dept. of Plant Pathology and Physiology, Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

Host range studies of Endogone gigantea were conducted with a population collected in a tobacco field in Nottoway County, Virginia and increased on tobacco in the greenhouse. County, Virginia and increased on tobacco in the greenhouse Twenty zygospores were added to sterilized soil in 15 cm pots. The treatments consisted of single seedlings of (1) Zea_mays ('Hy x C103') (2) Secale cereale ('Balboa') (3) Glycine_max ('Lee') (4) Nicotiana tabacum ('NC 95') transplanted into infested pots and (5) a no plant check. Each treatment was replicated five times. Two months after transplanting the greeness of Endoarne verse wheel from transplanting, the zygospores of Endogone were washed from the roots and counted. The average number of spores per plant for each treatment were (1) 85, (2) 71, (3) 9, (4) 83, and (5) 7. These data indicate that 'Lee' is a poor host of Endogone gigantea as compared to 'Hy x Cl03', 'Balboa' and 'NC 95'.

ENVIRONMENTAL FACTORS EFFECTING SPECIFIC DIURNAL CYCLES IN THE LAFAYETTE RIVER, NORFOLK, VA. Burton M. Golub and H. G Marshall, Dept of Biology, Old Dominion University, Norfolk, Va. 23508.

Diurnal studies were made at a station on an urban tidal estuary located on the Lafayette River in Norfolk. Va. from June to December 1971. A total of eight collection periods were recorded. Biological and chemical parameters monitored included temperature, salinity, dissolved oxygen, light penetration, extractable chlorophylls, phytoplankton quantities, and predominant phytoplankton species. Cloud cover, precipitation, and wind conditions were also noted. Samples were taken at both the surface and the three meter level at four hour intervals. Results showed salinity and temperature stratification during the warmer months, with more homogenous conditions existing during the colder months. Dissolved oxygen increased with decreasing temperatures.
Diurnal oxygen maximums were recorded in late afternoon. Diurnal chlorophyll and plankton quantities increased during the early morning and late aftermoon hours. Seasonally, chlorophyll and plankton reached maximum values in late July and decreased to a minimum in November. December showed the beginnings of an increase of these two charac teristics. Predominent phytoplankters included diatoms in the summer and flagellates in the autumn. Tidal fluctuations, combined with the "bottleneck" shoreline, appeared to have an effect on population densities.

MARINE LIGNICOLOUS FUNGI OF THE LOTER CHESAPEAKE BAY. P. W. Kirk, Jr. Dept. Biology and Oceanography, Old Dominion Univ., Norfolk, Va. 23508

Thirty spp. of wood-decay fungi, including 12
Ascomycetes and 8 Deuteromycetes unreported from Va., were collected at mouths of the James and York River estuaries. Tabulating world distributions in relation to Feb. isotherms of the oceans showed 11 spp. to be cosmopolitan, 15-16 temperate. and 3 tropical. Several cosmopolitan and snowed 11 spp. to be cosmopolitan, 15-16 temperate, and 3 tropical. Several cosmopolitan and temperate spp. predominated year-round, whereas 3 temperate fungi occurred mainly Sept.-April, and 2 tropical ones May-Aug. Fungal indicators of continuous tropical or cold temperate climates were lacking, as were brackish water fungi. Distribution patterns of <u>Lulworthia</u> spp. suggested that spore length in the <u>cosmopolitan</u> genus forms a cline governed by water temperature or viscosity.

Early colonizers were distinguished from climax Farly colonizers were distinguished from climax fungal associations on wood incubated 24 months in the lab. Fusarium spp. and Allescheria boydii were abundant on incubated panels that had been submerged in the estuaries, but lacking on incubated driftwood. This observation plus reported growth of similar fungi anaerobically without Sporulating, suggests that some unspecialized fungi are significant in temperate marine ecosystems, possibly disseminating as hyphal fragments.

NOTES ON ARCTIC AND SUBARCTIC AGARICS FROM ALASKA AND ADJACENT CANADA. G. A. Laursen, O. K. Miller, Jr., and D. L. Manning. Dept. of Biology, VPI & SU, Blacksburg, Va.

Higher fungi have been collected in tundra habitats over 3 seasons. The study areas include: the St. Elias Mt. Range in Southeast Alaska and the Alaskan North Slope. Four taxa constitute new records for North America: Russula emetica Schaef. ex Fr. var. alpestris Boud., Russula xerampelina Schaef. ex Fr. var. pascua Moll. & J. Schaeff. Hebeloma pusillum J. Lange and H. marginatulum (Favre) Bruchet. Two species, including a <u>Lactarius</u> OKM 10316 and a <u>Clitocybe</u> OKM 10336 are found only in arctic tundra and appear to be new species. In the Alaskan Arctic, two species seem to be dominant decomposers namely: Naematiloma udum (Pers. ex Fr.) Karst., and Galerina subannulata (Sing.) Smith and Sing. Cystoderma amianthinum (Scop. ex Fr.) Fayod var typicum Sing. and Smith was found only in disturbed areas. Inocybe decipientoides Peck is reported for the first time, above the Arctic Circle.

General information is given on the occurence and abundance of these species in tundra plant communities. The sensitivity of the fruiting responses to a subtle moisture gradient is discussed.

A STUDY OF THE IMPACT OF THE EXOTICS LONICERA JAPONICA THUNB. AND AILANTHUS ALTISSIMA (MILL.) SWINGLE ON THE SHENANDOAH NATIONAL PARK ECOSYSTEM. Paul R. Lee, 11* and J. Elwood Fisher, Madison Col., Dept. of Biology, Harrisonburg, Va. 22801

The officials of the Shenandoah National Park have anticipated the threat which certain exotic plants may present to the native plant associations. More than one hundred exotic plant species have been discovered on or near homesites in the park.

Most of these species have died or are dying out. <u>Ailanthus altissima</u>, the Tree of Heaven, is well established in many areas at all elevations. It can compete effectively with native species.

<u>Lonicera japonica</u>, the Japanese Honeysuckle, is readily naturalized at elevations less than 2500 feet where light is sufficient.

Seven quadrates in the Swift Run Gap area have been carefully studied for one year. Ecological data, growth rate measurements, and related information has been recorded weekly at these sites.

Conclusions have been reached concerning major limiting factors affecting each species, the threat each presents to the re-establishment of native forest species, and the measure of control necessary to regulate their advancement into the park ecosystem. (Aided in part by a grant from the Natural Sciences Res. Project, National Park Service)

COCCOLITHOPHORES IN THE COASTAL WATERS OFF THE EASTERN UNITED STATES. Harold G. Marshall. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508.

Phytoplankton collections were obtained from predominantly shelf waters off the eastern coast of the United States between the Gulf of Maine and Florida. The coccolithophores were discussed specifically in relation to their geographical distribution and species composition. A total of 66 coccolithophores were identified. The greatest diversity of species occurred in the Gulf Stream where 40 species were noted. These were compared to forms found in the cold currents coming down the Nova Scotia coast. The cold water form of Emiliania huxleyi, Syraco-sphaera pulchra, S. molischii, and S. tuberculata were noted as the dominant of nine species found in this colder current. Emiliania nuxleyi, found in the cold, warm, and intermediate forms, was ubiquitous. The total numbers of coccolithophores generally increased along the transects seaward. Of special interest was the extensive distribution of the diatom species in the genus Melosira over the entire sampling area. (Supported by NSF grant GB 13906).

NOTES ON THE DISTRIBUTION OF THE BETULACEAE (BIRCH FAMILY) IN /IRGINIA. Peter M. Mazzeo. U. S. Nat. Arboretum, Agricultural Res. Service, U. S. Dept. Agriculture, Washington, D.C. 20002.

Recent field and herbarium studies have produced some new distribution data about the Betulaceae (Birch Family) in Virginia. These additional data will be incorporated in a treatment of this family for a proposed flora of Virginia.

The Betulaceae, growing naturally throughout the various physiographic provinces of the state, is represented in Virginia by five genera containing 12 specific taxa. In addition to the indigenous taxa, a few exotic species have been planted for experimental purposes. With naturalization some of these exotics may become elements of the established flora in certain areas of the state.

Although the range maps and data included in this paper may show some gaps in the distribution for certain taxa, continued field and herbarium studies will bridge many of the gaps, and produce a better known distribution pattern for each member of the Betulaceae in the Old Dominion.

VEGETATION OF A PIEDMONT RAVINE. Heather McClanahan*. Longwood College, Farmville, Va.

The ravine at Allen's Mill, Prince Edward County, Virginia, contains a deep gorge surrounded by granitic flat-rocks—a topographical feature not commonly associated with the Piedmont. Where unusual topographical features are found, one may also expect the vegetation to be unusual. This expectation was supported by fact after making a vegetational study of the ravine. Two hundred and three plant species, representing 66 families, were collected and identified. Twenty-four species are associated with the granitic flat-rocks of the area; 8 species are rare to the Piedmont and/or occur extremely locally. The topography seems to be largely responsible for the unusual vegetation.

POPULATION DYNAMICS OF VIGUIERA PORTERI. A. Clair Mellingen Dept. of Life Sciences, E. Menn. Col., Harrisonburg, VA 22801

<u>Viguiera porteri</u> is an annual composite endemic to the fall-line granite outcrops of Georgia and Alabama. Because of its sharply delimited habitat, it serves as an excellent species for a plant population dynamics study. Four factors affecting the size of the <u>V. porteri</u> plant and seed populations were emphasized: seed germination polymorphism, summer drought stress, vegetative and reproductive plasticity, and loss of seeds washed from the population. Numbers of seeds produced, seeds dormant in the soil, seeds germinating, and plants surviving to reproduce were presented for a <u>V. porteri</u> population for the years 1967-1969.

THE TRIBE CICHORIEAE OF COMPOSITAE IN VIRGINIA. C. L. Nessler*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185
The Cichorieae is the only tribe in the sub-

The Cichorieae is the only tribe in the subfamily Liguliflorae of the family Asteraceae (Compositae). Members of this tribe can be distinguished from other composites by their heads of perfect, ligulate flowers and sap of milkywhite latex.

This study is a systematic treatment of the Cichorieae excepting the genera Hieracium and Prenanthes, in Virginia. Data was obtained from eleven herbaria, and from observations and collections made in the field. All counties in Virginia were visited during collecting trips in the spring and summer of 1971.

A total of 1257 specimens were examined and annotated, including 381 which were collected personally. Of these 381, approximately 206 represent the only material seen from the county of origin.

Twenty-six species were studied; of these, it was found that seven species occur mostly in the western portions of Virginia, four occur mostly in the east, nine are ubiquitous, and six are restricted or local in distribution.

SOYBEAN TISSUE CULTURE, NITROGEN METABOLISM AND ph. <u>L. C. Olson</u>, Dept. of Biology, Christopher Newport Col., Newport News, Va. 23606

Analysis of soybean tissue grown on Murashige skoog Revised Medium (RM) indicated that about 95% of the medium nitrogen was present in the tissue when it was supplied with optimum levels of cytokinin and auxin. This soybean tissue showed a nitrogen content of 6.5% compared to 3-3.5% for tobacco tissue.

Under conditions of optimum hormone levels, the dry weight increase was higher for growth with Miller's medium which has only 57% of the nitrogen of the revised medium. Again essentially all the nitrogen added to the medium was accounted for in the tissue. A study of the growth of soybean tissue with varying levels and sources of nitrogen showed maximum growth at levels of nitrogen lower than the RM.

Data from suspension cultures of soybean cells suggest that the reason for the lower growth at higher levels of added Nitrogen is due to a drop in pH to 3.5 which accompanied the selective use of ammonia initially. The nitrate present in the medium was subsequently used and there was a concomitant rise in medium pH to slightly above the initial value at the end of growth.

The tissue culture media currently in use seem inadequately buffered. Higher levels of phosphate to $10^{-1}\rm M$ increased growth and lessened pH changes.

THE CURATIVE EFFECTS OF TWO SYSTEMIC, FUNGITOXIC BENZIMIDAZOLES ON "MIMOSA" SEEDLINGS EXHIBITING FUSARIUM WILT SYMPTOMS. P. M. Phipps* and R. J. Stipes. Dept. Plant Pathology and Physiology, Va. Polytech. Inst. & State Univ., Blacksburg, 24061.

Two systemic, fungitoxic benzimidazoles, benomyl (B) and thiabendazole (T), were tested for their curative effects on Fusarium wilt of "Mimosa" (Albizzia julibrissin). Six-weekold seedlings grown in Weblite in the greenhouse were treated by drenching the growth medium at the time of initial wilt symptoms with various levels (100, 300 µg/ml) of either B or T in water suspension. Symptom expression was recorded weekly, and growth (fresh wt) and pathogen survival were determined at harvest. The test was performed twice, and the degree of symptom expression was 15 and 35 per cent, respectively, at the time of treatment. B-treated plants in the first test responded by a 32 and 40 per cent recovery 5 weeks after treatment at the 100 and 300 µg/ml levels, respectively. In the second test, in which a higher treatment level (500 µg/ml) was included, only B at this level produced a curative effect. Seven weeks after treatment, the curative effect of B was lost and plants again succumbed to disease. In both tests, T at the higher levels (300, 500, 100, 100) and plants effects were observed. The decreased frequency of recovery of the pathogen in culture and increased plant growth determined at harvest further confirmed the curative effect of B treatments.

PHYTOPLANKTON SUCCESSION IN THE LAFAYETTE RIVER, NORFOLK VIRGINIA. Thomas W. Purcell and Harold G. Marshall. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508

A seasonal phytoplankton study was conducted in the Lafayette River estuary, Norfolk, Virginia. Composition and concentration values are given with successional patterns for the phytoplankton at two stations in the river. Oxygen, temperature salinity, and chlorophyll parameters were obtained as part of the sampling method. Preliminary results indicate a marked difference in population density between the two sites; with lesser differences in the types of species. The successional pattern appears to be a modified bi-modal expression with the winter and spring dominated by diatoms and fall dominated by the phytoflagellate. There appears to be some extension of this latter stage due to a subsequent warming trend. Dominant species were those expected for the region; these include Skeletonema costatum (Greville), Rhizosolenia fragilissma Bergon, and Gymnodinium splendens Lebour. A great number of varied species were identified in the river system, mostly in small numbers. The influence of physical and chemical factors are discussed in relation to their influence to phytoplankton patterns.

STABILITY OF TAXONOMIC CRITERIA IN THE CHYTRIDIALES.

Martha K. Roane. Dept. of Biology, Va. Polytechnic Inst.
and State Univ., Blacksburg, Va. 24061

Characters used for taxonomic criteria in the Chytridales were studied in 20 single-sporangium isolates of 4 species of chytrids (Chytridium ottariensis, Chytriomyces hyalinus, Phlyctochytrium powhatensis, and Rhizophydium sphaerocarpum) on 4 media and 8 natural substrates. Variation was examined among strains of the same species and also among the 4 species. Location of thallus, position of resting spores, and presence of catenulate apophyses were not constant within any strain for any medium or substrate. Size of sporangia, size of resting spores, size and shape of zoospores, and type of thallus development were reliable taxonomic characters.

DISTRIBUTION OF AQUATIC PHYCOMYCETES IN ANT-ARCTICA. Hugh Rooney* and Dr. Robert A. Paterson. Dept. of Biology, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Soil and water samples, collected in various areas of Victoria Land and Ross Island during January and February, 1972, are being examined to determine occurrence and distribution of chytrids and Oomycetes. The areas selected were divided into four major groups: (1) penguin rookeries, (2) dry valleys, (3) coastal areas, and (4) areas inhabited by man.

In preliminary data from the investigation of one third of the samples, fungi occurred in 27% of the samples from coastal areas, 24% from areas inhabited by man, 16% from the dry valleys, 11% from the penguin rookeries, and 22% from the lakes near penguin areas. Transects through the penguin rookeries of Cape Royds and Bird indicated higher percentage frequency of occurrence of chytrideaceous fungi at the margin of the nest areas than in the center of the rookeries.

TRANSLOCATION RELATIONSHIPS BETWEEN TOMATO AND <u>OROBANCHE</u>
RAMOSA L. A. R. Saghir*, <u>C. L. Foy</u>, C. R. Drake and S. A.
Tolin. Dept. Plant Path. & Physiol., Va. Poly. Inst. &
State Univ., Blacksburg, Va. 24061

Branched or hemp broomrape ($\underline{0}$. \underline{ramosa}), a common phanerogamic root parasite of solonaceous and leguminous crops in semi-arid regions of the world, readily parasitizes tomato ($\underline{Lycopersicon}$ esculentum L. 'Rutgers') under greenhouse conditions. Structural aspects of the parasitic relationship were examined by light and electron microscopy. Solute translocation between species was studied by autoradiography and counting at intervals following administration of $^{14}\text{CO}_2$ to tomato and/or $\underline{0}$. \underline{ramosa} in photosynthesis chambers.

The vascular system of a functioning haustorium is simple structurally. Continuity of xylem and undifferentiated parenchyma exists between the haustorium of the parasite and the root of the host; however, there is no evidence of interconnecting sieve tube elements. Radiolabeled metabolites in tomato were readily supplied to the attached parasite. However, transport of $^{14}\mathrm{C}$ from tomato to broomrape in the dark or from parasite to host in either light or dark was negligible after several hours.

No structures analogous to chloroplasts were observed in thin sections of leaf or stem tissue of the parasite. Furthermore, acetone extracts of $\underline{0}$. $\underline{\text{ramosa}}$ shoot tissue failed to show absorbance in the spectral regions corresponding to chlorophylls a and b.

VASCULAR FLORA OF THE YORKTOWN COLONIAL PARKWAY BETWEEN KINGS CREEK AND BRACKENS POND. Emily D. Salle*. Dept. of Biology, Col. of William and Mary, Williamsburg, Va. 23185

The purpose of this study is to permanently record the vascular flora of the Yorktown Colonial Parkway between Kings Creek and Brackens Pond, York County, Virginia. The area studied extends approximately 4.4 miles along both sides of the Parkway making the total land area included about 265 acres. Major vegetational communities present include (1) roadsides and clearings (2) woods (3) salt marshes (4) beaches and (5) ponds and freshwater marshes.

Some of the most interesting specimens collected were Carex divisa, Aureolaria virginica, Malaxis spicata, Helianthus occidentalis, Boehmeria nivea, and Ligustrum sinense. The following plants were conspicuously abundant in the study area: Lonicera japonica, Myrica cerifera, Lindera benzoin, Senecio aureus, Callicarpa americana, Spartina spp., and Allium ampeloprasum var. atroviolaceum.

Of the specimens collected there were 492 taxa repre-

Of the specimens collected there were 492 taxa representing 109 families and 317 genera. Of the species found three were state records, 96 were Peninsula records and 312 were county records.

AN ORDINATION OF PLANT SUCCESSION IN THE GREAT DISMAL SWAMP OF VIRGINIA. Susan W. Walker* and Gerald F. Levy. Dept. of Biology, Old Dominion University, Norfolk, Va. 23508. Fourteen different areas were analyzed as to environ-

mental parameters and vegetational composition. Using ordination techniques as a tool to discover possible interrelationships, it was shown that in most cases the existing communities could be categorized by soils: peaty soils with a high water retention capacity versus mineral soils with a low water retention capacity. An Index of Reproduction based on the densities of the tree and sapling layers and the numbers of different species in each of these layers was developed to indicate the state of fluctuation within a given stand. In each stand the tree layer was compared to its sapling layer using the Index of Similarity (2w/a+b) to determine potential similarity of composition. Both wetter and drier stands exhibited variations in their state of fluctuation, as well as in degree of similarity between their tree and sapling layers. The composition of the sapling layers of some stands studied provides evidence of similar successional trends on wetter and drier sites despite substrate compositional stability. Other successional patterns also are evident.

SUBSTRATE TYPE AND DISTRIBUTION OF ROCK OUTCROP PORTULACACEAE. Stewart Ware. Dept. of Biology, College of William and Mary, Williamsburg, Va. 23185

In the genera Portulaca and Talinum in the eastern and central United States there are several rock outcrop species whose distribution closely parallels that of outcrops of a certain type. <u>Portulaca smallii</u> is found on granite outcrops of the southeast; <u>Talinum calcaricum</u> on the limestone cedar glades of Tennessee and northern Alabama. Talinum mengesii is confined to sandstone outcrops centered in north Alabama, except for a few relict populations on granite in Georgia; Talinum teretifolium distribution centers on gran-ite outcrops in the Piedmont from Georgia to Virginia, with outlying populations on serpentine and sandstone. In Missouri and Arkansas, Talinum parviflorum is found on sandstone but never on limestone, and Portulaca mundula, like the introduced Portulaca oleracea occurs on limestone, sandstone, and granite. Among those plants broadly circumscribed as Talinum calycinum different forms (species?) occur on sandstone, shale, granite, and perhaps limestone. Recent experiments have shown that there has been much physiological ${\tt specialization}$ in these two genera toward adaptation to a particular substrate and pH, explaining some of these parallels between distribution and substrate type.

IN VITRO STUDIES OF ADVENTITIOUS ROOTING IN CON-VOLVULUS SEPIUM L. William A. Wells, James L. Riopel, John H. Duesing* Dept. of Biology, Univ. of Va., Charlottesville, Va. 22903

Root production in excised nodes and internodes of <u>Convolvulus sepium</u> is reported. All auxin-like compounds promoted rooting. In the presence of indoleacetic acid, gibberellin and kinetin were inhibitory to rooting. Early stages of root development were particularly sensitive to gibberellin inhibition.

The number of adventitious roots induced by IAA was significantly less in nodal sections. Removal of the foliar organs increases the rooting competence of the nodal sections to levels comparable with internodes. Methanolic extracts of nodes with intact axillary bud and leaf reveal a root inhibitor active in the mung bean bioassay. Thin-layer chromatography of these extracts shows the inhibitor has Rf values of 0.53-0.73. Assays of fractions obtained after the removal of the foliar organs no longer show inhibition. (Aided by NIH grant HD 29-05)

INTRODUCED <u>SEQUOIA SEMPERVIRENS</u> IN SOUTHEASTERN VIRGINIA. E. <u>Spencer Wise</u>, Department of Biology, Christopher Newport College, Newport News, Va. 23606.

Sequoia sempervirens (Lamb.) Endl. has been introduced into the Norfolk, Virginia, area as an ornamental. One tree dates from at least 1863, and is now 35.9 inches diameter breast height. Another specimen, probably planted in this century, is now 33.5 inches diameter breast height. A number of seedlings were planted in Norfolk and Chesapeake in the 1930's and appear to be growing well. Normally there is no winter damage to the foliage, but damage has been noted following the unusually cold spell of January, 1972. The two largest and oldest trees and one younger tree examined have suffered top damage at some time in the past and are considerably shorter than trees of their respective diameters would be expected to be.

Section of Chemistry

Fiftieth Annual Meeting of The Virginia Academy of Science May 3—5, 1972, Lexington, Virginia

ESCA STUDY OF GROUP IIB HALIDES. R. W. Alexander, Jr., L. T. Taylor, and J. G. Dillard, Dept. of Chemistry, Va. Poly. Inst. & State Univ., Blacksburg, Va., 24061

An x-ray photoelectron spectroscopic study of the core electron binding energies of several Group IIB halides, especially mercury, has been carried out. Binding energies were measured for core electronic states with large photoionization cross sections. These states were $4f_{5/2}$, $4f_{7/2}$ for mercury and various states for halogens. The difference in binding energy relative to known standards is defined as the chemical shift. The chemical shifts will be explained using concepts of electron densities and partial charges. Differences between the binding energies of selected ${\rm Hg}({\rm I})$ and ${\rm Hg}({\rm II})$ compounds will be discussed. Surprisingly, the binding energy of ${\rm Hg}({\rm I})$ is greater than that of ${\rm Hg}({\rm II})$ in compounds containing the anions C1- and S04-2.

REDUCTION OF COBALT (III) COMPLEXES BY POSITRONIUM. L. J. Bartal*, and H. J. Ache. Dept. of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, 24060.

Kinetic studies on the reduction of various cobalt (III) complexes by positronium are described. The rates of reactions between positronium and the cobalt (III) complexes were determined by delayed coincidence techniques. Rate constants ranging from 1.9 x 10 9 to 3.1 x 10 10 liters moles $^{-1}$ sec $^{-1}$ (at 25 $^{\circ}$ C.) were measured for the reactions of positronium atoms with Co(NH $_3$) $_5$ F $^{2+}$, Co(NH $_3$) $_5$ Br $^{2+}$, Co(NH $_3$) $_5$ Cl $^{2+}$, Co(NH $_3$) $_5$ Mr $_5$ Co(NH $_3$) $_5$

SYNTHESIS AND BIOLOGICAL EVALUATION OF INHIBITORS OF HMG-CoA REDUCTASE. M. R. Boots*, Sharon G. Boots*, Dept. of Chemistry and Pharmaceutical Chemistry, and K. E. Guyer, Dept. of Biochemistry, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219.

BINDING ENERGY STUDIES OF COBALT COMPLEXES. <u>J. Burness</u>, J. G. Dillard, and L. T. Taylor, Dept. of Chemistry, Va. Poly. Inst. & State Univ., Blacksburg, Va., 24061

A short history of ESCA will be reviewed, after which a description of the principles, applications and techniques of the method will be described. Specific details will be given about the AEI ES-100 x-ray photoelectron spectrometer which has been used for these binding energy studies. Pertinent information about sample preparation and introduction into the spectrometer will be presented. Methods of data acquisition and time-averaging will be described. Comments will be made concerning preliminary binding energy studies of core atomic levels for cobalt metal, $\cos 20$, $\cos 30$,

DETECTION OF DRUGS OF ABUSE IN HUMAN URINE. J. M. Chin* and R. M. Navari. Dept. of Chemistry, Hollins College, Virginia 24020.

The detection of drugs of abuse in the urine has recently elicited much interest due to the need for a rapid, sensitive, and accurate analytical identification technique. There exists a wide variety of analytical procedures for the detection of acidic, basic, and neutral drugs which primarily employ chromatographic analyses. However, there does not exist good norms for choosing a specific analysis.

This work presents criteria for employing a particular analysis based on theoretical considerations of the structures of the drugs. Application of the criteria to the acidic, basic, and neutral drugs illustrates that it is possible to meet the requirements of a clinical technique. A particular procedure is proposed which allows the detection of drugs at a concentration level of 2-5µg drug/ 1 ml. of urine.

AN INVESTIGATION OF SIMPLE NUCLEAR REACTIONS ON ZIRCONIUM ISOTOPES USING RADIOCHEMICAL METHODS.
Kathleen Cline* and R. Kiefer, Deot. of Chemistry,
College of William and Mary, Williamsburg, Va. 23185

Several (0,2p) reactions on isotopes of Several (0,2p) reactions on isotopes of zirconlum have been studied. The reactions are Zr^{94} (p,2p)Y 93 , Zr^{92} (p,2p)Y 91 , and Zr^{91} (p,2p)Y 90 . Protons with energies of 100, 300, and 400 MeV were used. The radioactive yttrium products were chemically separated from the target material. The yields were determined by following the radioactive decay of the yttrium isotopes. The simple nuclear reactions, such as the (p,2p) reaction, are basically surface reactions. The results will be discussed in terms of surface effects.

A CHEMICAL APPROACH TO THE HOST-PARASITE A CHEMICAL APPROACH TO THE HOST-PARASTE RELATIONSHIP IN THE CHEST'UT BLIGHT. AN INTRODUCTION. John Rush Elkins and Grenda Meade.* Chemistry Dept., Bluefield State Col., Bluefield, W.Va. 24701 A brief history of the origin, spread, economic and esthetic consequences, and preventive measures attempted to control the spread of the chestnut

blight will be presented. Referral will be made to the chemical and biological research carried out to date. Finally, a report on current approaches, including results from our laboratory, will be given.

THE USE OF INTERACTION OF FOUR CONFIGURATIONS IN THE CALCULATION OF PRINCIPAL AXES OF POLYACCHES IN THE TRIPLET STATE.

L. Ivan Epstein, Dept. of Biophysics, Med. Col. of Va., Va.
Commonwealth Univ., Richmond, Va. 23219.

The calculation of principal axis orientation of FSP of polyacenes in the triplet state has been described in a recent paper (J. Chem. Phys. 56, 1779 (1972)). If the molecule is much more long than wide, the principal axes tend to align themselves with the length and width of the molecule.

If the three lawest-energy configurations are mixed it is If the three lowest-energy configurations are mixed, it is found that relatively large changes in the proportions of the mixture in the vicinity of optimum bring about only minor changes in principal axis orientation. However, there exists another mixture far removed from ontinum in whose vicinity principal axis orientation is also relatively insensitive to changes in the proportions of the mixture. In a mixture of the four lowest-energy configurations, insensitivity of rincipal axis orientation to proportions of the mixture remains only in the vicinity of ontimum, which shows that the ether insensitive case was sourious. In the mixture of four configurations, the two mutually degenerate configurations have been taken to be present in equal amounts. Fyidence will be presented to show that changes in their relative amounts will not produce any large changes in principal axis orientation.

ADVENTURES IN PRACTICAL ADMLYFICAL CHROISTRY. H. I. Fainstein. Dept. of Themistry, George Mason Univ., Fairfax, Va. 2203C Some personal case histories are recounted.

Some personal case histories are recounted. Emphasis is placed on the chemical thinking that contributed to the solutions of a number of analytical problems. Among the cases discussed are the application of nioxime to nickel in steal, the assay of beryllium metal, the uranium-thiocyanate reaction in the analysis of uranium ores, and the uranium-azide complex.

A CHEMICAL EVALUATION OF THE SEDIMENT COMPOSITION OF THE RAFPAHAMMOK RIVER AND ITS SFFSCT ON THE SURVIVAL OF AQUATIC LIFE. Barbara P. Friedman* and Bernard L. Mahoney, Jr. Dept.

of Chemistry, Mary Washington Col., Fredericksburg, Va. 22401 In connection with a broad study of the Rappahannock River Ecosystem, a chemical profile of the surface water and sediment have been determined over an eighty mile range. Measurements were mide on acidity, dissolved oxygen, water hardness, and temperature. Chemical analyses were carried out for Na,K,Mg,Ca,Si,Al,Fe,Cu and Zn using atomic absorption, emission spectrographic and specific ion electrode methods. Many of these elements had sediment concentrations that ranged from ten to over a hundred fold elevations compared with water samples from the same site.

Previous bloadsay studies in our laboratories have shown that low prm concentrations of Zn and Cu are toxic to bluegill sunfish in the relatively soft water found in the Rappahannock River. A synergistic effect involving Cu and Zn gave TL_m of 0.27 ppm Cu and 2.40 ppm Zn under coft water gave Π_m of 0.27 pin th and 2.40 pin 21 when not water conditions. The concentration of these metals in the river are considerably below these values, but in the case of sediment samples the TL_m levels are greatly exceeded at sediment samples the Thm levels are greatly exceeded at certain sites near Fredericksburg. In their present bound state in the sediment, they do not present a serious threat to aquatic life; however disturbances of the river sediment due to variation in dissolved oxygen, acidity or flow conditions could release these metals in a soluble form, posing a danger to aquatic life.(aided by COSIP-NSF Grant)

ANTIMALARIALS 3. SUBSTITUTED

✓ -(DIALKYLAMINO-METHYL)-3-PHENYL-1-NAPHTHALENEMETHANOLS. J. S. Gillespie, Jr., S. P. Acharya* and R. E. Davis. Va. Inst. for Scientific Res, Richmond, Va. 23229.

Several <-(dialkylaminomethyl)-3-phenyl-1-naphthalene-</pre> methanols patterned after the <-(dialkylaminomethyl)-2phenyl-4-quinolinemethanols have been prepared for evaluation of their antimalarial activities. The syntheses involved the preparation and cyclization of appropriately substituted 3, 4-diphenylbutane derivatives of the general structure:

$$X \xrightarrow{CH_2 - CH - CH_2 - CO - R} Y$$
 $R = CH_3 \text{ or OH}$

The antimalarial activities of the naphthalenemethanols compared very favorably with the activities of the quinolinemethanols and, in contrast to the quinolinemethanols, they were not phototoxic to albino mice.

RING-CHAIN TAUTOMERS, O-CARBONYL BENZOIC ACIDS AND AMIDES. <u>T. A. Gosink</u>, Dep't. of Chemistry, Old Dominion Univ., Norfolk, Va. 23508, and P. R. Jones, Dept. of Chemistry, Univ. of N.H., Durham, N.H. 03824.

Spectroscopic evidence will be presented to show that 2 and 4 predominate in the tautomeric equilibria of the parent systems shown below, and in several substituted

In dimethylsulfoxide-d6 the methylene protons of 4 and related compounds are nonequivalent in their nmr

SOLVOLYSIS REACTION OF ALKYL-SUBSTITUTED HALOALLENES. F. L. Griffith and M. D. Schiavelli,

Dept. of Chemistry, College of William and Mary, Williamsburg, Va. 23185

The solvolysis of six trisubstituted halo-allenes is reported. The solvent dependence and the activation parameters are found to be typical of S_Nl reactions. The data are interpreted in terms of a unimolecular reaction proceeding via a charge-delocalized allenyl cation. Substitution of \underline{t} -butyl groups at the propargylic position of the cation encourages reaction at the allenyl position. The change in relative rate for ϕ substitution is interpreted in terms of steric inhibition of resonance in the cation.

RELATIVE ABSORPTION OF Ca-45 AND Sr-89 BY SOME SOIL FUNGI. J.E. Hardcastle, Dept. of Chemistry, Texas Woman's University, Denton, Texas and W. H. Fuller, Dept. of Chemistry, University of Arizone, Tuscon.

Fungi are abundant in nature and may well be a link in the transfer of soil radiocontaminents to the food chain of man. Fungi isolated from calcareous desert soils were grown in liquid Czapek's medium containing different ratios of calcium and strontium. Ca-45 and Sr-89 were used as tracers of these elements, and these isotopes were counted by liquid scintillation spectrometry. The measured Sr/Ca ratios in the test organism and in the nutrient medium were used to calculate the discrimination factor (DF).

D.F.= (Sr/Ca)in organism/ (Sr/Ca)in medium D.F.= (ST/Ca)In organism/ (ST/Ca)In medium All the test organisms absorbed both calcium and strontium from the culture medium though the ST/Ca ratios varied from fungi to fungi. Based on the calculated D.F. values the soil fungi may be grouped as follows: 1) those organisms that discriminate in favor of calcium; 2) those that discriminate in favor of strontium; and 3) those that appear to absorb strontium in proportion that appear to absorb strontium in proportion to the amount of this element in the medium.

HIGH-TEMPERATURE SAMPLING TECHNIQUES IN THE CHEMICAL SHOCK TUBE. <u>Shen-Dat Ing</u> and G. Sanzone, Dept. of Chemistry, VPI & SU, Blacksburg, Va. 24061

The chemical shock tube provides a well-established technique for the study of high-temperature gas-phase reaction kinetics. Although both optical spectroscopic and mass spectrometric detection methods have been employed in such studies, the results obtained by these two different techniques have not always been in complete agreement.

In this paper, some of the sources of error in the mass spectrometric sampling technique are discussed and a new experiment is described which will allow a critical comparison of the optical and mass spectrometric methods as applied to shock tube sampling.

THE SILVER (I) COMPLEXES OF SOME SUBSTITUTED CYCLOALKENES. G. M. Kauffman* and D. G. Kennel*, Dept. of Chemistry, Eastern Mennonite College, Harrisonburg, VA 22801

The equilibrium constants for the formation of the Ag⁺ complexes of some cyclic olefins in ethylene glycol have been determined. The gas chromatographic technique of Muhs and Weiss [J. Am. Chem. Soc., 84,4697 (1962)] was utilized. The retention data were obtained on ethylene glycol columns containing 0.0, 0.3M and 0.5M AgNO₃ at 28°C. The partition coefficients were linearly related to the Ag⁺ concentration on these columns. Two series of alkyl substituted cyclopentenes were studied along with several cyclohexenes. following complexing constants, K1, were obtained (values relative to cyclopentene are in parentheses). R-Cyclopentene:

R = H: 6.61 (1.00); 3-Methyl: 7.85 (1.19); 3-Ethyl: 6.01(0.91); 3-isoPropyl: 4.64 (0.70); 3-t-Butyl: 1.67 (0.25); 4-Methyl: 4.50 (0.68); 4-Ethyl: 4.38 (0.66); 4-isoPropyl: 4.58 (0.69); 4-t-Butyl: 4.24 (0.64). R-Cyclohexene:

R = H: 3.37 (0.51); 3-Methyl: 3.24 (0.49); 4-Methyl: 2.87

Steric effects appear to be important in the 3-R-Cyclopentenes but are, notably, absent in the 4-R-series. The differences between these two series also suggest a positive inductive effect although this is not as apparent in the cyclohexene series. The possibility of conformational effects will also be discussed.

PROTON NMR STUDY OF SOME AMINE-IODINE SYSTEMS. M. J. KOGAN* and J. C. Schug, Dept. of Chemistry, V.P.I.&S.U., Blacksburg, Va. 24061.

When I_2 is added to butyl amine, the NH resonance peak shifts downfield. The maximum shift observed is about 3.5 ppm, and is limited by the solubility of I_2 in the amine. With \underline{t} -butyl amine, it is possible to isolate a stable solid I:1 adduct. However, with \underline{sec} -butyl amine a rapid chemical reaction occurs: I_2 is reduced to iodide; amine is oxidized to a symmetric hydrazine; the HI which is produced forms quaternary ammonium salts. The observed NH proton chemical shift is a weighted average of several species which exist in equilibrium. For the \underline{sec} -butyl amine $-I_2$ system, a series of NMR experiments was carried out to determine the equilibrium constants for several postulated equilibria as well as the proton chemical shifts for some isolated and some postulated species.

CHEMICAL PERTURBATIONS OF OSCILLATING REACTION SYSTEMS

J. F. Lefelhocz and D. W. Carew, Chemistry Department, Virginia

Commonwealth University, Richmond, Virginia 23220.

Studies of the two oscillating reaction systems, (I) malonic acid,

potassium bromate and ceric ammonium sulfate and (II) malonic acid, potassium bromate and manganous sulfate have been made potentiometrically with Pt, Pt-black electrodes. Our primary objective has been to elucidate the feedback mechanisms which control the cyclic changes of $\left[\text{Ce}^{+4}\right]/\left[\text{Ce}^{+3}\right]$ and $\left[\text{Mn}^{+3}\right]/\left[\text{Mn}^{+2}\right]$ in the respective systems. The induction period, period of oscillation and longevity of the oscillations in I and II have been observed as a function of the metal ion concentration and the acidity of the solution. The cyclic potentiometric curves have been shown to be due to three different reaction sequences, A-the oxidation of the metal ion by BrO₃-, B-the reaction of bromine with malonic acid and C-the feedback step which involves the reduction of the metal ion by the malonic acid. The time for the third step to occur may or may not be auto-catalytically controlled by the BrO₃ system as noted by the shorter period for II as compared to I (all factor being equal). Solutions of the chemical perturbants KBr, Br₂, NaCl, ferroin, 1, 10-phenanthroline and ferrous ammonium sulfate were added to I and II after oscillation had begun and the effects noted. Br_2 and Br^- have been ruled out as the feedback controlling substances. Correlation of the visual effects of the perturbant ferroin and its constituent parts with the potentiometric data will be discussed.

MÖSSBAUER STUDIES OF SOME SUBSTITUTED UREA AND SULFOXIDE COMPLEXES OF IRON (III) CHLORIDE. J. F. Lefelhocz and J. T. Green, Chemistry Department, Virginia Commonwealth University, Richmond, Virginia 23220.

Mössbauer spectra at 77°K have been observed for the DMSO (dimethylsulfoxide), DPSO (diphenylsulfoxide), U (Urea), DMU (dimethylurea), and TMU (tetramethylurea) complexes of Fe(III)Cl. *6H,O. Infrared data have shown S=O→Fe and C=O→Fe coordination to be present in all of these complexes. Earlier I.R. and X-ray studies showed that the FeCl $_4$ anion forms in both the DMSO and DPSO complexes. Wide single line Mossbauer absorptions with slight shoulders indicate that the complexes have Fe(III) present in two different coordination symmetries. NaBPh₄ has been used to inhibit the formation of FeCl₄-, allowing the direct observation of the spectra of the DMSO and DPSO complexes. DMSO has been shown to form stronger ligand Fe bonds as compared to DPSO, where as the DPSO complex has a greater distortion from octahedral symmetry. The spectral data for FeU, Cla rule out the possibility that its structure is similar to that of FeCl₃• 6H₂O . The Fe(III) complexes of DMU and TMU yield very wide lined spectra indicative of the presence of more than one type of iron site and NaBPh₄ has been noted to prevent the formation of some of those iron symmetries. The NaBPh4 complexes have shown that FeCl4 does not exist in the urea complexes. Data obtained on Fe(II)X2 (Cl, Br, I) DMSO and DPSO complexes will also be presented.

METALATIONS OF ALCOHOLS USING N-BUTYLLITHIUM AND N-BUTYLLITHIUM-TMEDA. ACID CATALYZED CYCLIZATIONS OF THE CONDENSATION PRODUCTS TO FORM CYCLIC ETHERS. R. E. Ludt* and K. N. McGrath, Dept. of Chemistry, Virginia Military Institute.

When compared with n-butyllithium alone, n-butyllithium N,N,N', N'-tetramethylethylenediamine (TMEDA) reagent was shown to be better for effecting the lithiation of benzyl, 2-methyl benzyl and other structurally similar alcohols. Positions and extent of metalation were determined by deuteration and by condensation of the intermediate lithiated alcohols with deuterium oxide and electrophilic compounds, respectively. The resulting condensation products of the various alcohols used in this investigation were readily cyclodehydrated to yield substituted five and six membered ethers.

The resolution of the Time-of-Flight Mass Spectrometer is limited by the initial spacial (space resolution) and energy (energy resolution) distributions which the ions to be analyzed have on their formation. It has been shown that energy resolution is the limiting factor and that the two-field ion-source yields the best energy focus for conventionally focussed T.O.F.'s. Calculations are described which test a proposed method for improving the energy resolution of a two-field instrument. These studies could lead to a new method for focussing the T.O.F. Mass Spectrometer. In these studies, a new criterion for the discussion of resolution is introduced.

SOME THERMODYNAMIC PROPERTIES OF POLYETHYLENE + N-DECAME SOLUTIONS. Virginia A. McKay*, Thomas W. Eppes, Jr.*, and Robert A. Orwoll. Dept. of Chemistry, Col. of William and Mary, Williamsburg, Va. 23185

The pressure of n-decane vapor in equilibrium with a solution of linear polyethylene in decane has been determined at 150°C over the concentration range 50--90 wt-% polymer. The chemical potential of the solvent in the solution, determined from these vapor sorption measurements, is compared with theoretical values. The latter have been computed from equation-of-state properties of the two liquid components and an interaction parameter which has been evaluated from properties of binary solutions of low molecular weight n-alkanes. (Aided by NASA grant NGL-47-006-055)

THE PHOTOREDUCTION OF SUBSTITUTED BENZOPHENONES. G. W. Mushrush, Dept. of Chemistry, George Mason Univ., Fairfax,

Substituted benzophenones were irradiated with ultraviolet light in degassed isoprpyl alcohol in the presence of different concentrations of $\rm TbCl_3$. The chemical quantum yield of ketone conversion and the sensitized-Tb $^{+3}$ fluorescence quantum efficiency were determined. The quantitative kinetic data derived are consistent with a mechanism in which energy transfer to the lanthanide ion acceptor competes with the hydrogen abstraction reaction of the n, π^* triplets. Rates of photochemical conversion under continuous irradiation predicted by the calculated parameters agree well with experiment. (Aided by NIH 2166-1000,2188-

A NEW PREPARATION OF THE Co[P(OCH₃)₃]₅⁺ ION.

R.A. Palmer and Susan A. Levy.* Dept. of
Chemistry, Old Dominion Univ., Norfolk, Va. 23508.

It has been found that [Co(NH₃)₅H₂O](ClO₄)₃
reacts with trimethyl phosphite to produce
[CoL₅]Cl, where L = trimethyl phosphite. This is a more straightforward preparation than that previously reported for the perchlorate and nitrate salts of the CoLy+ ion, in which Co(II) disproportionates to produce Co(I) and Co(III) trimethyl phosphite complexes, and requires several recrystallizations for purification.

THE ISOTHERMAL COMPRESSIBILITY OF ORGANIC LIQUIDS BY ULTRA-CENTRIFUGATION - CORRELATION WITH SURFACE TENSION. A. J. Richard, Dept. of Chemistry and Pharmaceutical Chemistry and K. S. Rogers, Dept. of Biochemistry, Medical College of Virginia, Virginia Commonwealth University, Richmond, Va.

Isothermal compressibilities of seven organic liquids have been determined by analytical ultracentrifuge techniques, in good agreement with literature values obtained by other methods.

A least squares regression equation was derived that correlated the logarithmic values of isothermal compressibilities of 7 organic liquids, determined experimentally, with the liquids' surface tensions. This equation was shown to be valid for 11 other organic liquids (values obtained from literature) over a temperature range of 0° through 50° , and a surface tension range of 13 to 44 dyn per cm.

USE OF DOUBLY-EXCITED CONFIGURATIONS IN CALCULATIONS OF ELECTRONIC SPECTRA. P. J. Schultz* and J. C. Schug, Dept. of Chemistry, V.P.I.&S.U., Blacksburg, Va. 24061

The Pariser-Parr-Pople method with configuration interaction including singly- and doubly-excited states was used to calculate the electronic spectra of a variety of conjugated compounds. Inclusion of the doubly-excited configurations dictated some changes in the optimum values for the semi-empirical core-Hamiltonian and electron-repulsion integrals. Agreement with experiment for a series of hydrocarbons required an unusually low value for the one-center repulsion integral on carbon. Good results were obtained for another series of molecules by making relatively minor changes in parameters. The results for a series of \underline{p} -quinones indicated that the inclusion of doubly-excited states can substantially improve predictions when heteroatoms are present. Consistently satisfying results were obtained when the total number of excited configurations was around 80, with about a 1:1 ratio of singly-excited to doublyexcited states. This corresponds roughly to including configurations with excitation energies less than about 11 eV above the self-consistent ground configuration. (Aided by a grant from NASA.)

THE BINDING ENERGIES OF MQ (M = GROUP IIB; Q = GROUP VIA). R. D. Seals, J. G. Dillard, L. T. Taylor, Dept. of Chemistry Va. Poly. Inst. & State Univ., and J. R. Craig, Dept. of Geology, Va. Poly. Inst. & State Univ., Blacksburg, Va.,

The core electron binding energies of MQ compounds (M = Group IIB; Q = Group VIA) have been measured using x-ray Photoelectron Spectroscopy. Binding energies in the atomic levels $np_{1/2}$, $np_{3/2}$, $nd_{3/2}$, $nd_{5/2}$, $nf_{5/2}$ and $nf_{7/2}$ where n is an appropriate quantum number were determined. The binding energies relative to the elemental state, the chemical shift, have been measured for all compounds. As the chemical environment of a metal is varied, the core electron binding energies change. A comparison of the binding energies of various chalcogenides in different crystal structures will be presented. The variation of the chemical shift as a function of environmental change on the cations and also on the anions will be discussed. The relationship between binding energies and electron density, partial charge, and electronegativity will be considered.

A STOCHASTIC MODEL FOR THE SIMULATION OF THE MOTION OF POLYMER CHAINS IN SOLUTION. J. M. Spencer and D. E. Kranbuehl, Dept. of Chemistry, College of William and Mary, Williamsburg, Va.

The dynamic and equilibrium properties of a random-coil polymer in dilute solution are studied using a Monte Carlo simulation method. The model consists of N beads on a cubic lattice, each bead one lattice site apart. Motion of the chain is simulated by moving the beads using a random number generator. Excluded volume may be introduced ber generator. Reluted volume may be introduced by storing bead locations and by preventing the chain from intersecting itself. The equilibrium properties of ℓ^2 - the end-to-end length squared, ℓ^4 , and Rg² - the radius of gyration squared are sampled. The dynamic properties of the chain are studied by observing the relaxation of autocor-relation functions in these quantities. The stochastic model without excluded volume conforms well with the properties of a freely-jointed chain model of a polymer.

EVIDENCE FOR THE FORMATION OF APPARENT FIVE—COORDINATED TIN(IV)-B-DIKETONATE COMPLEXES: THE SYNTHESIS AND CHARACTERIZATION OF THE PYRIDINE ADDUCT OF n-BUTYLDICHLORO(2,4-PENTANEDIONATO)TIN-(IV). D. W. Thompson and G. Lock, Dept. of Chemistry, College of William and Mary, Williamsburg, Va. and J. F. Lefelhocz, Dept. of Chemistry, Virginia Commonwealth University, Richmond, Va.

The reaction of n-butyltrichlorostannane with 2,4-pentanedione in the presence of pyridine has been studied. From this reaction mixture the apparent five-coordinate n-butyldichloro(2,4-

The reaction of n-butyltrichlorostannane with 2,4-pentanedione in the presence of pyridine has been studied. From this reaction mixture the apparent five-coordinate n-butyldichloro(2,4-pentanedionato)tin(IV) was isolated as the pyridine adduct. The isolation of n-butyldichloro(2,4-pentanedionato)pyridine-tin(IV) represents the first direct evidence for the existence of monosubstituted tin(IV)- β -diketonate complexes although these types of intermediates have been postulated to form in route the many well-known bis(β -diketonato)tin-(IV) complexes.

The title compound has four possible geometric isomers. Temperature--dependent nmr measurements will be discussed in terms of the various structural possibilities.

A CNDO STUDY OF 2,3-DITHIABICYCLO[1.1.0]BUTANE.
C. O. Trindle*, University of Virginia, Charlottesville, Va. 22901 and <u>J. K. George</u>*, Mary Washington College, Fredericksburg, Va. 22401
In order to study the importance of d orbitals

in chemical bonding involving second row atoms, 2,3-dithiabicyclo[1.1.0]butane was chosen as a model compound. Some points on the potential energy surface of the unimolecular central bond scission to give a stable diradical molecule were computed using the CNDO approximation which includes d orbitals in the basis set for second row atoms. Energies along the indicated path of lowest energy for the isomerization were also obtained using sp and spp' bases. All three basis sets gave the same qualitative features for isomerization. The sharply bent parent bicyclic molecule was the most stable having a shorter than usual carbon-carbon (C-C) bond. A 'Planar Diradical' molecule was found at C-C distances of about 3 A. In addition, there was a second bent species having a relative minimum at an intermediate C-C distance. An explanation of these data is provided by the nodal properties of d orbitals and by orbital coupling.

SOME REACTIONS OF THE Cr(NO)EDTA COMPLEX. J.W. VanderMeer and J. G. Mason, Dept. of Chemistry, Va. Poly. Inst. and State Univ., Blacksburg, Va. 23219

A chromium(I) complex containing EDTA has been prepared both chemically and electrochemically. This complex was found to be reduced by Cr(II)-EDTA in basic solution and oxidized by 02, H202 or Ce(IV) in acid solution. In the absence of oxygen, this complex was found to be stable in slightly acidic solutions. The visible spectrum and ESR spectrum indicate that the first step in the oxidation process (CrI to CrIII) is probably the protonation and subsequent partial decomposition of the EDTA ligand.

The kinetics of the oxidation of this complex in acid

The kinetics of the oxidation of this complex in acid solution have been studied under saturated oxygen conditions. The rate constants are reported as a function of the acid concentration. The oxidation of this complex by Ce(IV) and $\mathrm{H_2O_2}$ will be discussed.

A NEW MODEL FOR THE NATURE OF LIGHT, AND ITS APPLICATION TO SPECTRAL DISTRIBUTION OF BLACK BODY RADIATION.

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Randolph-Macon Col., Ashland, Va. 23005

A new model for the nature of light is suggested as part of a program to bridge the gap between the wave properties and corpuscular properties of light. The current investigation is of the consequences of assuming that photons are comprised of integral numbers of elementary energy units. The particulate nature of light as described by Planck and Einstein should fit within such a framework.

As an initial test of the usefulness of this model, an attempt has been made to apply it to the problem of spectral distribution of black-body radiation. Statistical methods have been applied to establishedhe relative probabilities of emission of photons comprised of the various integer numbers of energy units as described above. The products of these probabilities and the energies of each such photon are plotted as the spectral distribution.

Preliminary trials indicating agreement between this model and the Planck distribution law will be presented and its limitations will be discussed.

POLYACYLAZIDES: THE THERMAL AND PHOTOLYTIC DECOMPOSITION OF THE 2,2'-BISACYLAZIDE OF 3,3'-BIPYRIDINE. R. L. Williams and M. A. El-Fayoumy. Dep't. of Chemistry, Old Dominion University, Norfolk, Va. 23508.

The synthesis and characterization of a new and interesting heterocyclic bis acylazide (1) will be described. Thermolysis of this new system has been shown to give rise to a stepwise degradation leading to various pyridonaphthyridones, (2). Photolysis of this same bisacylazide gives rise to an apparent isomeric pyridonaphthyridone (3).

Section of Engineering

Fiftieth Annual Meeting of The Virginia Academy of Science May 3–5, 1972, Lexington, Virginia

THE DESTRUCTIVE DISTILLATION OF USED TIRES IN A CONTINUOUS PILOT PLANT. J. A. Beckman*, Grant Crane*, E. L. Kay* and J. R. Laman*. The Firestone Tire & Rubber Co., Akron, Ohio 44317.

The volume of used tires as well as other scrap rubber being generated in the U.S.A. confirms that the Rubber Industry has a pressing solid-waste disposal problem. The Rubber Industry is investigating several processes to solve the problem.

The destructive distillation of scrap rubber, which is being studied by Firestone, has the potential of conserving our natural resources. Valuable materials can be recovered from scrap rubber and recycled to manufacturing operations.

Three primary crude products are obtained from the pyrolysis of scrap rubber: char, oil and hydrocarbon gas.

The char after grinding has reinforcing properties in rubber vulcanizates. The unground char can be steam-treated to increase surface area and may be a source of activated carbon.

The pyrolysis oil can be treated to obtain hydrocarbon resins which are of interest as tackifiers in the Rubber Industry.

The hydrocarbon has a BTU value approaching the value of natural gas. Our present proposal is to use the hydrocarbon gas as fuel for the "destructive distillation" process.

RESOURCE RECOVERY - AN ALTERNATIVE TO REFUSE DISPOSAL. G. F. Bourcier, R. F. Testin*, K. H. Dale*, Reynolds Metals Company, Richmond, Virginia

The philosophy of utilizing solid waste, particularly the municipal refuse fraction, as a source of raw materials is discussed. Research accomplishments resulting from Public Health Service: E.P.A. funded programs, U. S. Bureau of Mines intramural and contract programs, and University and Industrial research projects are highlighted. Data resulting from laboratory scale and community wide investigations are listed and discussed. The challenges of the solid waste problem to our society are enumerated, with these challenges converted into a charge to engineers to solve this problem.

STUDIES ON IRON AND MANGANESE REMOVAL FROM DOMESTIC WATER SUPPLIES IN VIRGINIA. D. M. Caldwell*, Virginia Dept. of Health, Lexington, Va., and P. H. King, Dept. of Civil Engineering, Virginia Polytechnic Institute and State University 24061.

An experimental investigation of the removal of soluble iron and manganese from water supplies by oxidative precipitation and filtration was carried out with potassium permanganate and calcium hypochlorite employed separately as the oxidant. Adjustment of water quality parameters including pH and alkalinity was accomplished on four raw water samples selected for the investigation. Each raw water sample was from a location in Virginia which has experienced a problem with iron and manganese in their water supply.

with iron and manganese in their water supply.

Results obtained showed potassium permanganate to be a very effective oxidant for both iron and manganese when the sample pH ranged from 6.0 to 9.5 and the alkalinity from 15 to 200 mg/l as CaCO3. The hypochlorite treatment resulted in acceptable iron removal in the pH and alkalinity ranges noted above. However, this oxidant proved to be unacceptable if used alone for removal of soluble manganese under these same pH and alkalinity conditions. The treated water was unable to meet the Public Health Service Drinking Water Standards. (Aided by a USPHS Traineeship)

HEAT ISLAND STUDIES OF URBAN SHOPPING CENTERS. <u>Kuldip P. Chopra</u>, W. Maurice Pritchard, and Kristine E. Thompson. Dept. of Physics, Old Dominion University, Norfolk, Va. 23508.

Neighborhood shopping centers with sharp spatial contrasts with the surrounding residential areas may exhibit pronounced heat island effects on a microscale. The data gathered in several field trips conducted on Wednesday and Friday afternoons, and on Wednesday nights during April, June, July, and August, 1971 is analyzed to establish the heat island effect associated with the Wards Corner and Southern Shopping centers in Norfolk, Virginia. The observed maximum amplitude of the effect on a relatively calm and clear day is 7°F. The influences on the heat Island effect of the sea breeze, gustiness, degree of cloud cover, traffic and urban activity, the day and night difference, and the differences in the local surface features are brought out. A numerical harmonic model is set up to provide a quantitative description of the symmetrical heat island; the higher harmonics determining the extent of the influence of other factors.

HIGH PURITY OXYGEN AERATION OF PROCESS WASTEWATER. R. Cline* and E. Cox III, Edwin Cox Associates, chmond, Va. 23223

Richmond, Va. 23223

Recent technological advances in the use of high purity oxygen aeration in the activated sludge process may benefit many industrial wastewater treatment programs. Higher concentrations of mixed-liquor volatile suspended solids (MLVSS), shorter aeration detention times, and improved sludge handling characteristics are some of the

reasons why oxygen use may often be superior to the conventional air-aerated process.

A simple, inexpensive pilot plant has been developed to determine the effectiveness of oxygenaerated systems in reducing biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and other parameters of

specific industrial wastewaters.

THE USE OF FLY ASH IN ROAD WORK AND LIGHTWEIGHT AGGREGATE. John H. Faber, National Ash Association, Washington, D.C. 20006

Coal ash utilization has come of age and is now widely accepted and used in heavy construction and road building. Ash from coal burning power plant is used in many forms from admixes to lightweight aggregate for concrete.

During 1971, in excess of 7 million tons of ash was used in the U.S. in one form or another. In Chicago, more than one million tons of stabilized base material containing ash was installed. In England, one structural fill application used approximately 2 million tons of reclaimed ash and in France, utilization of ash exceeded production.

Lightweight aggregate usage from fly ash is growing and the industry is anticipating sizeable growth in this area in the next few years.

We can expect increasing large amounts of the 40 million tons of ash produced in this country to be utilized in the civil engineering industry.

COST-BENEFIT ANALYSIS IN EVALUATING SCENIC RIVERS AS AN ALTERNATIVE IN WATER RESOURCE DEVELOPMENT. Michael A. Gagarine* and William R. Walker, Water Resources Res. Ctr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Craig Creek in Botetourt and Craig Counties, Va., is currently the center of a controversy concerning whether to construct the proposed Hipes Reservoir on that creek, to leave the creek in its natural state, or to have it designated a Scenic River. In the past, the evaluation of the alternatives has been hampered because of the difficulty of quantifying in dollars the intangible benefits such as natural scenic beauty and environmental conservation. This paper presents a technique for assigning economic values to these intangible benefits, thus facilitating comparison among the alternatives utilizing a conventional economic analysis. Craig Creek is used as a case study in the application of this technique.

APPLICATION OF AEROSPACE WASTE RECLAMATION TECHNOLOGY TO DOMESTIC WATER RECYCLING AND SOLID REDUCTION. J. B. Hall, Jr. NASA, Hampton, VA 23365

During the past decade waste reclamation technology has been developed to provide waste water recycling and solid waste management on broad manned spacecraft for long term missions. Since the waste materials and crew sizes involved are similar to those of an average size household, this technology has direct application to domestic waste reclamation to aid in water conservation and pollution abatement.

Presently, NASA Langley Research Ctr., programs are under way to integrate various aerospace developed waste reclamation subsystems into a household complex to obtain performance data on waste recycling schemes. Such domestic wastes as bath and clothes wash water will be processed and reused as toilet flush. Solids will be separated from commode and dish waste water and converted to sterile ash through reduction processes. In addition, an assessment will be made of the energy generated from the solid reduction to supplment domestic energy requirements.

A discussion of this program is presented which outlines

program objectives, recycling schemes, candidate aerospace waste reclamation processes and typical performance data for these processes compared with U. S. Public Health Stds. for potable water.

NUCLEAR STEAM SUPPLY SYSTEMS RADIOLOGICAL SOLID WASTE HAND-LING. J. H. Hicks* and $\underline{\text{T. L. Baldwin}}$ *. Power Generation Div., Babcock & Wilcox Co., Lynchburg, Va. 24505

The operation of a pressurized water nuclear steam supply systems requires a strict management of radioactive solid wastes. The wastes mainly consist of spent ion exchange resins, liquid wastes with dissolved and suspended solids that have been concentrated by evaporation, and such miscellaneous items as contaminated rags, paper, clothing, and plastics. These wastes are packaged in suitable disposal containers and transported to one of several sites in the United States for ultimate disposal. The containers, transportation facilities, and disposal sites must meet specific requirements based on federal and state regulations.

A rapid expansion in the use of nuclear power is forecast for the future, and there is a need for improved methods of reducing the solid waste volumes and the handling of ultimate disposal.

THE EFFECT OF HEAT ON ENGINEERING SOIL PROPERTIES. E. J Jankiewicz* and J. H. Hunter*. Dept. of Civil Engineering,

Va. Polytechnic Inst., Blacksburg, Va. 24061

The practicality of stabilizing soil by the application of heat is investigated. It is shown that researchers have conclusively demonstrated that any soil may be fused and that even a limited application of heat will increase the bearing capacity of cohesive soils. Other improvements in soil characteristics observed as a result of heating are (1) an increase in resistance to liquifaction; (2) an absence of differential compressibility; (3) an increase in cohesive, compressive, and shear strengths; and (4) a decrease in settlement under load when wet. This paper provides background material for future development of thermal roadpaving machines in the United States. An economic comparison is made of the costs of thermal paving versus construction by conventional means.

COMPOSTING ORGANIC WASTE TO HUMUS WITH SPECIFIC BENEFICIAL PROPERTIES. George A. Jeffreys*, George A. Jeffreys & Co., Inc., Salem, $\overline{\text{Virginia}}$. 24153

Organic wastes, including sewage sludge and paper, were converted to humus by composting in a series of bins which were aerated by means of submerged, perforated air cells. These cells permitted the air with slight pressure to diffuse through the composting waste. Humus in the stationary phase was automatically inoculated with nitrogen fixing bacteria and other beneficial soil organisms. The humus at this stage was recycled to increase the concentration of said organisms, and then was used as a sanitary animal litter or as a beneficial soil conditioner.

Sewage sludge produced by chemical and biological precipitation was heat treated, filtered, combined with a small amount of ground paper and composted to humus.

MECHANICAL FRICTION AND THERMAL EXPANSION OF SOLID POLYMERS FOR BEARING APPLICATIONS. Howard L. Price and Harold D. Burks.* NASA-Langley Research Center, Hampton, Va. 23365

Although the majority of polymers degrade rapidly in ionizing radiation, there are two, polyimides and Pyrrones, which are highly radiation resistant. Such polymers may be useful as low-maintenance solid bearing material in radiation fields. Accordingly, the coefficient of friction against two steels and the coefficient of thermal expansion from 300°-500°K have been measured for a polyimide, a Pyrrone, and a Pyrrone-graphite composite. It was found that the coefficient of friction of the Pyrrone and the Pyrrone-graphite composite were low (≈ 0.21) relative to that of the polyimide (≈ 0.35) for surface speeds up to 2 m/sec. The low value may be due to traces of sulfur which are present in the synthesis of the Pyrrones. All of the polymers had anisotropic thermal expansion as the result of the way in which they were molded. The expansion was higher in the direction in which the molding pressure was applied than it was perpendicular to that direction. The coefficient of thermal expansion of the polymers ranged from 20-60 x $10^{-6}/^{\circ} K$.

SOLID WASTE MANAGEMENT OF PLASTIC WASTES
L. D. Pritchard.* Civil Engineering Student, Virginia
Military Institute, Lexington, Virginia 24450

Plastics are a small but highly visible part of the overall problem of solid waste disposal. Today plastics are used in thousands of different products, from artificial heart valves to furniture that looks like wood and wears like iron. Even so, the largest amount of plastics in collected refuse comes from packaging. This makes up about 13% of all collected refuse.

All of this adds up to a massive social and economic problem. That problem, of course, disposal. If our environment is to be improved and protected for future generations, government, industry, and private citizens will have to work together to implement modern methods of waste disposal utilizing technology that is currently available.

The main concern of this thesis lies with how present solid waste management methods can be applied in the disposal of plastic solid waste, wholely or in combination with other types of solid waste.

One conclusion appears to be that if solid waste is effectively managed, plastics pose no speical problems over those currently incurred with disposal of mixed refuse.

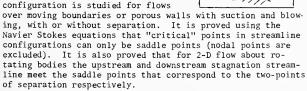
PRESENT AND FUTURE USES OF SANITARY LANDFILLS. W. F. Smith. Student, Civil Engineering Department, Virginia Military Institute, Lexington, Virginia 24450

The Sanitary Landfill is the most misunderstood method of solid waste disposal currently in use. The general public equates a Sanitary Landfill with controlled or uncontrolled dumps as a result of the poor disposal methods utilized by most municipalities in the past. The National Survey of Community Solid Waste Practices in conjunction with the Bureau of Solid Waste Management has identified over 13,000 land disposal sites in the United States. Less than 5% of the identified landfills could meet the minimum standards to qualify as a Sanitary Landfill. Minimum standards for a Sanitary Landfill include, no resulting air or water pollution, and a daily cover of earth surrounding compacted refuse cells. Sanitary Landfills are not just controlled dumps, they are the most practical, economical method of disposing of the nearly one billion pounds of mixed refuse created in this country each day.

The major limitations of Sanitary Landfills, including a large land requirement, can be easily outweighed with the recreational benefits derived from vertical landfills.

SADDLE POINT STREAMLINE CONFIGURATIONS IN TWO-DIMENSIONAL VISCOUS FLOW, D. P. Telionis, Va. Polytechnic Institute and State Univ., Blacksburg, Va. 24061.

It has been experimentally observed [1] that the stream-line configuration for separation over moving boundaries is that of a saddle point. Following the speculation of Moore, Rott and Sears the appearance of such streamline configuration is studied for flows



The boundary-layer equations for a downstream moving wall and for various pressure gradients are integrated in terms of Gortler coordinates and according to reference [2] from stagnation to separation. The displacements of the saddle point in the directions parallel and perpendicular to the wall are computed as functions of the wall velocity. These results are used to estimate the circulation according to Howarth's scheme of zero vorticity shedding. 1.Ludwig, G., AIAA paper 20-22, (1964) 2.Telionis, D., Werle, M. to appear in J. of Appl. Mech.

Section of Geology

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

VIRGINIA EARTHQUAKES DURING 1971. G. A. Bollinger, Dept. of Geological Sciences, Va. Polytechnic Inst. & State Univ.

Blacksburg, Va. 24061 On September 12, 1971 two earthquakes occurred in northeastern Virginia approximately 23 km. south of Fredericksburg. Data from four regional stations placed the epicenters at 38.1°N - 77.4°W with origin times and magnitudes of 00:06:27.1 (M_L \cong 3.5) and 00:09:22.6 (M_L \cong 3.2). An intensity questionnaire survey gave a maximum intensity (MM) of IV and a felt area of 1900 square miles.

The larger of the two shocks can be compared to the central Virginia earthquake of December 11, 1969. This latter event occurred some 35 km. to the south $(37.9^{\circ}N-77.7^{\circ}W)$, had the same magnitude and maximum intensity, but its associated felt area (6500 square miles) was more than three times greater. This wide variation in felt area for shocks within and outside of the Central Virginia Seismic Zone is important to earthquake risk studies. Without focal mechanism and focal depth data complete specification of the underlying seismic causes is, however, not possible.

STRUCTURAL EVOLUTION OF DRAG FOLDING ON THE SOUTHEAST LIMB OF THE JOHN'S CREEK SYNCLINE, GILES COUNTY, VIRGINIA. J. T. Crate*, and F. R. Nelson*. Dept. of Geological Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Drag folding in the Ordovician Martinsburg limestone along the southeast limb of the John's Creek syncline provides numerous interesting structures. Tight folds, faulting, and a great deal of distortion caused by plastic deformation and fracturing are characteristic structures. The area studied is close to the nose of this northeast-plunging syncline, and lies a considerable distance from its axis. evidence of a major fault in the area; the Saltville thrust lies 3 miles to the southeast and is separated from the area by the Spruce Run syncline and the Clover Hollow anticline. Thus the structures developed in the Martinsburg are due to the characteristics and composition of the rocks themselves. The interbedded thin but rather competent limestones and thinner, plastic-yielding shaly limestones of the Martinsburg comprise a weak structural unit whereas the overlying Ordovician Juniata and Silurian sandstones and the underlying Eggleston and Middle Ordovician limestones comprise competent units. The small-scale parasitic structures of the Martinsburg were produced at the same time as the major folds and reflect the marked difference in the way in which these beds responded to regional stress.

PALEOENVIRONMENT OF ISOGNOMON MAXILLATA. Pamela R. Crowson. Dept. of Geology, College of william and Mary, Williamsburg, va., 23185.

Fopulations of Isognomon maxillata (Deshayes) were collected from the St. Mary's Formation (middle Miocene) of Mansfield (1943) on the lower James-York Feninsula near williamsburg and near Sycamore Landing on the York River. The shells, recovered from thick beds of fine sand composed of quartz, glauconite, and shell debris, occur in recovered from thick beds of fine sand composed of quartz, glauconite, and shell debris, occur in beds or lenses and are current oriented. They exhibit abrasion of the thin ventral margins, and bore holes of Pholadidae are frequently found near the hinge line of Isognomon. An analysis of shell morphology indicates that Isognomon was a gregarious, byssally attached filter feeder. The associated fauna includes a predominance of shallow burrowing mollusks, and abundant Septastrea marylandica, byssally attached and free-swimming pectens, Ealanus concavus, and boring sponges. wone of the sessile benthos were found attached to Isognomon. Analysis of shell orientation, shell morphology, and the associated faunal assemblage indicates that Isognomon flourished on shoals in warm temperate to subtropical waters.

EVALUATING THE EFFECT OF AREAL SEISMICITY ON BUILDING CONSTRUCTION. T. A. Dumper*, Dept. of Geological Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

The design of a building to withstand the effects of earthshaking is a trade off between its ability to withstand the effects of earth tremors and economies in construction cost. Such design is based upon the relationship between the damage potential of an earthquake and its return period. This relation may be determined by plotting the function relating the intensity (I) of an earthquake felt within a given area with its recurrence interval (Log $N=a+b\ I$). This function may be quantified by estimating on the basis of historical record, the number of recurrences of each intensity of earthshaking felt in a given area during the maximum record length attainable for that area.

This method is demonstrated for an area in Central Botetourt County for which 27 episodes of earthshaking related to earthquakes has been recorded since 1774. The plot of the recurrence function was found to have the equation Log N = -1.58 -.25 I and the maximum credible earthquake for the area would be Intensity VIII with a recurrence interval of .027 or about once in 370 years. It was concluded that building construction that has extensive useful life, that is used to accommodate large groups of people, or that would provide a special environmental hazard in case of failure should consider an earth-quake of Intensity VIII in its design. GRAVITY AND MAGNETIC STUDY OF THE NORTHWEST RIVER AREA. R. J. FENNEMA*, M. A. Sabet, Department of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

The fact that most river channels in the Coastal Plain of Virginia trend NW-SE, strongly suggests that their locations and trend is structurally controlled. It is hypothesized that these channels reflect faulting in the basement complex.

To test the hypothesis, gravity and magnetic maps of the Northwest River area were made based on detailed observations. This river was chosen because of its short course and narrow channel; thus data could be obtained from equally distributed locations.

The magnetic map displays a series of NW-SE-trending anomalies on the north side of the River. These anomalies change their trend to NE-SW on the south side. Similarly, the gravity contours swing from NW to a SW direction across the river. It is thus concluded that this channel may indeed reflect faulting in the basement complex.

STUDY OF THE RELATIONSHIP BETWEEN BEDROCK AND SLOPE NEAR BUCHANAN, VIRGINIA. G. C. Grender and T. A. Dumper*. Dept. of Geological Sciences, Va. Polytechnic Inst. and State

Lithology and slope in a 31-square-mile area near Buchanan, Virginia are so closely related that it is possible to infer generalized bedrock distribution from slope alone. An elevation and a lithology were assigned to each point in a 75 x 137 grid (10,275 points) with uniform 300 foot spacing. Computer routines calculated the maximum slope at each point and made slope frequency distributions for each of fifteen mapping units. In this area, slopes up to 10% are associated mainly with alluvium, those from 10% to 35% mainly with limestone and dolomite, and those greater than 35% mainly with quartz sandstones. The groups are distributions, which may reflect the difference between dip slopes and outcrop slopes.

MAGNETIC AND PETROGRAPHIC STUDY OF THE HARRISON-BURG DIKE. O. L. Hoover,* Dept. of Geology, Madison Col., Harrisonburg, Va. 22801.

The Harrisonburg Dike was surficially and magnetically mapped and found to run continuously for approximately 2.5 miles. Magnetometer surveys indicated the major portion of the dike to be located somewhat to the west of its position as originally mapped by Brent, 1960.

Petrographic (mineralogical) studies of thin sections made from samples throughout the extent of the intrusion revealed the igneous rock to be an olivine diabase composed of the minerals olivine, augite, labradorite, chlorite, and magnetite. Mineralogical composition of the dike remains unchanged throughout its extent.

Strike and dip measurements were made of joint patterns within the carbonate rocks through which the Harrisonburg Dike intruded. This information, combined with the magnetic profiles and nearly horizontal bedding of the carbonate rocks, strongly indicates that the intrusion was joint controlled.

PETROLOGIC ASPECTS OF A COMPLEX AREA IN THE PETERSBURG GRANITE AT RICHMOND, VIRGINIA. <u>David R. Huber</u>, College of William and Mary, Williamsburg, Virginia 23185

At the Fall Line, several distinctive rock types crop out in a one acre area along the south bank of the James River. A biotite gneiss (BG) containing lenticular, poikiloblastic plagioclase and quartz is injected by a microcline quartz monzonite (QM) with fine, medium, and pegmatatic phases. In turn, this is intruded by a foliated chloritic microcline biotite granodiorite (GD). A lighter, coarser non-foliated GD intrudes biotite schist farther up stream. Late kinematic aplitic QM dikes and pegmatites, and veins of pegmatite and quartz filling joints cross all rocks. Regional metamorphism raised all to greenschist facies. The BG occurs as xenoliths and massive parallel units as much as 20 feet long injected lit-par-lit by the QM forming an arteritic migmatite. This can be demonstrated by chilled margins, cross cutting dikes with rotated xenoliths, assimilation, and by tracing the QM free of inclusions into the BG where it has schlieren and rotated xenoliths. Non-dilation pegmatite dikes are products of replacement. A venitic model is appropriate for dikes with mafic borders and septa of biotite paralleling the foliation of the BG and extending into the dikes undisturbed. Ptygmatic folds suggest a plastic state caused by anatexis which differentiated the paleosome into melanocratic restites and leucocratic mobilizates, some with porphyroblasts of quartz and microcline forming constipated veinlets. Dikes with poikiloblastic texture may represent relic bedding.

A LATE MIOCENE BALEEN WHALE FROM THE YORKTOWN FORMATION AT HAMPTON, VA. G.H. Johnson, G.D. Armstrong, M.B. Barney, J.C. Blush, R.R. Ellison, B.J. France, J.R. Gustafson, G.E. Holt, P.M. Hopkins, J.S. Norman, S.A. Nunnally, J.B. West, J. Westgate, and T.Z. Wilke, Dept. of Geology, College of William and Mary, Williamsburg, Va.

A fossil baleen whale was recovered from the leached and oxidized part of the silty-sand facies of the Yorktown Formation at Dellinger pit near Langley Field, Hampton, Virginia. These deposits (Orionina vaughani biozone of Hazel, 1971) are late Miocene or early Pliocene in age. Although extensively fractured, the skeleton (skull, left jaw, ribs, and cervical, thoraic, and lumbar vertebrae) were only slightly disarranged. The appendages and caudal vertebrae were not recovered. The fauna found directly below the skeleton was composed mostly of mollusks. The texture and composition of the sediments, primary structures, orientation and physical condition of the fossils, and ecology of extant genera and species indicate that the whale lived in marine waters 50 to 150 feet deep. THE INVESTIGATION OF ILCIONIC "EMBATICS" AND A CONGLOMMERIE ALONG THE LEADING 2008 OF THE PULASKI THAUST FAULT, NORTH OF BLACKSBURG, VA. L. F. Johnson III*, and C. D. Lee*, Dept. of Geol. Sciences, VPI & SU, Flacksburg, Va. 24061

Recently, tectonic "erratics" have been found locally within a recess in the leading edge of the Pulaski thrust sheet east of US 460, north of Blacksburg. "Erratics" of "jasperoid" and "erratics" composed of brecciated enert and dolomite apparently were plucked from the overriding pper Cambrian Elbrook dolomite. "Erratics" of strained and brecciated quartitic sandstone and conglomerate were derived from the underlying hississipian formations. The direction of tectonic transport was from south to north.

The "erratics" led to the discovery of several outcrops of Conglomerate above the Mississippian Naccrady redbeds. Petrographically, the conglomerate is similar to another nighly strained conglomerate occurring above the Maccrady redbeds Within the Price Mountain Window, south of Blacksburg. This Occurrence represents the only known possible source for the conglomerate "erratics" found along the leading edge of the fault. Therefore, the maximum distance of tectonic transport for these "erratics" is probably less than five miles.

HEAVY MINERAL DISTRIBUTION IN PLEISTOCENE SEDI-MENTS FROM SOUTHEASTERN VIRGINIA. Anne K. Kolesar* and W. J. Hanna. Geophysical Sciences Department,

Old Dominion University, Norfolk, Virginia 23508 Samples of Pleistocene sediments were collected from test borings of two sites in Southeastern Virginia. One site was near the eastern edge of the Dismal Swamp. Samples taken at this site ranged from 40 to 65 feet. The other site was between the eastern and western branches of the Lynnhaven River where sampling depths were from 10 to 30 feet. Two samples were taken from Recent dunes for comparison.

Samples were dry sieved and the 60 to 80 and 80 to 100 mesh fractions were selected for heavy mineral separation on the Frantz Isodynamic Magnetic Separator (Model L-1). Portions of the separated fractions were mounted in lakeside cement on glass slides and ground to thin section thick-

ness. Minerals were identified by petrographic microscope under plane polorized light.

Varying amounts of ilmenite minerals were found, along with leucoxene in all samples. Of the ferromognesians, hornblende and augite appear to be the most represented minerals.

Philip S. Marshall.* Dept. of Geology, Col. of William and Mary, Williamsburg, Va. 23185
Goshen Pass, Rockbridge County, Virginia, is located in the Valley and Ridge province of the Central Appalachians (Goshen 72 Quadrangle). The stratigraphic section exposed in the Pass consists of Middle Ordovician to Middle Silurian clastic rocks encompassing, in ascending order, the Martinsburg Formation, Oswego Sandstone, Clinch Sandstone, Cacapon Formation and Keefer Sandstone. The Oswego-Keefer interval, estimated to be approximately 1000' thick, forms a competent

GEOLOGY OF GOSHEN PASS, ROCKBRIDGE COUNTY, VIRGINIA.

rock layer enclosed between the incompetent Martinsburg and Devonian shales.

Structures trend northeast in Goshen Pass. Major structures are the Wolf Mountain and Chambers Ridge anticlines and two back-thrust faults. The combination of folds and faults causes six repetitions of the Oswego-Keefer sequence. The structures probably record a single episode of deformation in which the faults are slightly older than the folds.

The back-thrust faults dip northwest and are overthrust to the southeast, a geometry and movement opposite to that typical of the general region. The faults resemble west-dipping thrust faults in the Appalachian Plateau province which Gwinn (1964) explains as flexural-slip responses to compression in the cores of concentric folds. This explanation is applicable because on a larger structural scale Goshen Pass appears to lie on the western flank of a major anticline. (Aided by NSF Grant GY-8771).

SUBSURFACE COMPLEXITIES OF THE VIRGINIA COASTAL PLAIN RE-VEALED BY GRAVITY AND MAGNETIC STUDIES, M. A. SABET, Depart-ment of Geophysical Sciences, Old Dominion University, Norfolk, Virginia 23508.

A simple Bouguer anomaly map was made for the area extending eastward from 77°00 W to the Atlantic Coast between 37°00'N and 37°37.5'N. The map is based on 850 gravity observations made on the subaerial Coastal Plain, and published the subaerial coastal Plain and subaerial coastal Plain, and published the subaerial coastal Plain and subaerial lished observations in Chesapeake Bay. In addition, total magnetic intensity maps of portions of the same area were made based on ground surveys.

The Bouguer map shows three distinct anomaly trends: N-S, NE-SW, and NW-SE. The magnetic maps show that every gravity enomaly is associated with a similar magnetic enomaly. It is thus inferred that density and magnetic susceptibility contrasts between the rocks of the crystalline basement and the overlying sediments are the main causes of both gravity and magnetic anomalies.

Quantitative interpretation of the gravity map suggests that the Coastal Plain sediments are underlain by a topographically rugged crystalline basement, probably of structural origin. Changes in the depth to the basement from 700 to 7000 feet within 10 or 15 miles are very common. The topography of the basement appears to be reflected on the surface by some major physiographic features. For example, the Surry and Suffolk scarps, as well as the York and lower James Rivers are located where faults in the basement com-

plex are most suspected. SEQUENCE OF STRUCTURAL DEFORMATION EXHIBITED BY DRAG FOLDS IN MIDDLE ORDOVICIAN STRATA IN THE CLOVER HOLLOW ANTICLINE,

GILES COUNTY, VIRGINIA. Mark L. Slusarski*. Dept. of Geological Sciences, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

Drag or parasitic folding is a common type of structural deformation one is likely to encounter in the folded and faulted Valley and Ridge Province of the Southern Appalachians. The Clover Hollow anticline is comprised of Lower to Middle Paleozoic sediments of which the Moccasin and Eggleston formations (Middle Ordovician) have been so deformed. The term drag folding is incorrect, however, as it implies a specific type of deformational process.
Plastic deformation of the beds and flexural folding of alternately interbedded competent and incompetent units of the Moccasin-Eggleston sequence resulted in parasitic folds formed by the same deforming stresses that affected the area on a regional scale. With continued stress, shear planes, boudinage, cleavage and wedging were produced. Normal and reverse faulting of the lithified units subsequently fractured, jointed and displaced the folded beds.

PETROLOGY AND ORIGINS OF THE SCHISTOSE XENOLITHS OF THE PETENSBURG GRANITE. C. K. Sever , Col. of William and Mary, Williamsburg, Va. 23185

The dark schistose xenoliths in the body of the Peters-

burg granite were studied from locations at Richmond and in Dinwiddie County at the Jack Quarry. Field observations show rather distinct contacts between the host rock and the xenoliths. Xenoliths vary in size from inches to several feet. Orientation is random, and many of the xenoliths exhibit curved laminae along the contacts with the granite where drag has occurred during rotation accompanying granite emplacement. No primary features are relict, and no reaction of the xenoliths with the host rock is obvious.

Petro ϵ raphic study shows the dominant mineral assemblage to be hornblende, epidote, plagioclase, and biotite. Chlorite, pyrite, and sphene are common accessories. Veins of quartz and plagioclase occur in many of the xenoliths parallel to foliation and as distinct ptygmatic folds. Texture and mineralogy suggest a medium grade of regional metamorphism, specifically one of the quartz-albite-epidote subfacies of the greenschist facies. The composition suggests a former iron- and calcium-rich mineralogic assemblage probably in a sedimentary environment.

Rocks similar to a possible source material for the xenoliths exist northwest of the Petersburg granite as an amphibolitic gneiss body. Samples of this from Sabot, Va., show a mineralogy similar to the xenoliths.

(Aided by NSF Grant GY-8771)

METAMORPHIC ZONES AS DETERMINED BY STUDY OF STREAM SEDIMENTS IN THE JAMES RIVER BASIN OF THE VIRGINIA PIEDMONT. Stephen M. Snyder*, College of William and Mary,

Williamsburg, Va. 23185.

A study of metamorphic index minerals in stream sediment A study of metamorphic index minerals in stream sediments amples suggests a useful means of reconnaissance to determine metamorphic isograds in the Piedmont province of Central Virginia. 30 sand sized fractions of sediment obtained at 100 localities along small tributaries within a 2500 square mile area in the James River drainage basin were analysed to determine relative abundance as well as the total absence or presence of key minerals studied.

The study revealed a well-defined axis of maximum meta-

morphic intensity in the sillimanite zone bisecting the area in a narrow north-south trending belt approximately 10 miles west of Richmond. A distinct garnet zone flanks the axis to the east, with kyanite occurring locally between these zones. To the west of the sillimanite zone, metamorphic intensity decreases through garnet and biotite zones to a concentrated area of kyanite surrounding Willis Mt. near Dillwyn, Va. Westward of Willis Mt., garnets reappear and grade into a distinct staurolite zone near the eastern edge of the Blue Ridge.
(Aided by NSF Grant G7 -8771) VERTEBRATE REMAINS FROM A (?)POST-WISCONSIN FISSURE DEPOSIT NEAR PEARISBURG, VIRGINIA. R. E. Weems*. Dept. of Geol. Sci., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061

A small vertebrate fauna has been found at the abandoned

Ripplemead Limestone Company quarry on the western bluff of the New River near Pearisburg, Giles County, Virginia. The fauna was collected from three small fissures in the quarry wall. Each fissure was filled with breccia and red clay weakly cemented by calcite. Numerous land snails' shells are present as well as bones and teeth. The most numerous remains are snake vertebrae and rodent bones and teeth. Also a few teeth of larger mammals such as horse, peccary, deer, bear(?), and bobcat(?) have been found. Only one vertebra of a fish and two vertebrae of a salamander have been recovered. This suggests that the fissures were not suitable for creatures dependent upon a continuous water supply or prolonged dampness, and the fissures were therefore above the water table when they were filled. The complexion of this fauna, although certainly prehistoric, is not very ancient. Assignment of this fauna to post-Wisconsin time is warranted for this reason. 14 dating can be made, it is hoped that a maximum downcutting rate for the New River can be estimated. Such a dating might also allow an estimate of the latest time at which horses and grasslands still existed in western Virginia.

Section of Materials Science

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

AN ELECTRICAL MEANS OF MONITORING CLOT FORMATION. T. H. Boyd, III*, G. E. Stoner. Department of Materials Science, University of Virginia, Charlottesville, Virginia 22901

Successful implantation of materials in the bloodstream requires the material to be antithrombogenic, that is, not inducing clot formation on its surface. In vitro blood clotting experiments using plasma give results that are similar to those done with whole blood. A method used in this laboratory for monitoring the clotting of plasma has been to measure the change in turbidity with a photoelectric device by passing light through the plasma. As polymerization proceeds the amount of transmitted light decreases with turbidity producing a sigmoid curve. Recently, it was also found that the electrical resistivity of the plasma increases with increasing turbidity, also displaying a similar sigmiod curve; thus offering as alternative method of monitoring the polymerization of either plasma of whole blood. In addition, the resistivity curve continues to increase after the optical turbidity curve has leveled off, and undergoes a distinct inflection several minutes after the original polymerization -- thus indicating continued chemical activity which may be attributed to crosslinking. With this added sensitivity, an explanation of the final steps in clot formation and/or lysis could possibly be explained and monitored as a function of time.

DYNAMIC TENSILE RESPONSE OF ANNEALED COPPER WIRES. T. H. Dawson. Dept. of Civil Engineering, Univ. of Va., Charlottesville, Va. 22901

The plastic response of copper wires to impact tensile loadings is examined experimentally using results derived from general viscous and non-viscous similarity relations and from an appropriately constructed theory as indicated by the similarity considerations. For maximum strain rates ranging from 1 to 11/sec, the plastic response is found to be governed by a non-viscous time-independent constitutive law having dynamic stress values for any given strain consistently greater than those determined from quasi-static considerations.

A COMPUTER SIMULATION OF ELECTRONIC SWITCHING IN AN AMOR-PHOUS SEMICONDUCTOR. L. R. Durden, W. D. Leahy, Jr.*, and L. H. Slack. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ. Blacksburg, Va. 24061

Inst. and State Univ., Blacksburg, Va. 24061

The switching characteristics of amorphous semiconductor thin films are compared with a computer simulation of switching based on a thermal runaway model. The model consists of applying a square wave voltage pulse through the semiconducting glass film between two electrical contacts. Effects of changing the electrode areas, film thickness, semiconducting glass resistivity and applied voltage have been explored via the computer simulations. The delay time for the thermal runaway varies very sensitively with each of the parameters except electrode area.

Experimental studies of switching for amorphous semi-conductor devices of similar geometries reveal that a minor electronic switch occurs prior to thermal runaway. This phenomenon is accompanied by 15MH_Z oscillations. A comparison of the experimental and simulation results indicates that this minor switch, when it occurs, greatly reduces the delay time for thermal runaway. (Aided by ARPA Grant 1562, Amend. No 1.)

STERIC AND ENERGY MAPPING OF POLYPEPTIDE CONFORM-ATIONS. J.H. Fikus* and R.A. Johnson, Dept. of Materials Science, Univ. of Va., Charlottesville, Virginia 22901

The polypeptides which make up proteins are linear unbranched chain polymers which may assume different three-dimensional shapes or conformations by rotations about the single bonds of its covalent backbone and side chains. With various hard-sphere contact criteria, steric maps have been generated using computer modelling techniques, and illustrate the dominant roll of steric hindrance (i.e. repulsive forces) in restricting chain folding. Since the hard-sphere model implies an infinite-step potential, it yields no insight into the stability due to attractive forces. For energy calculation, a Buckingham 6-exp potential function representing the non-bonded interatomic interactions was used. Potential energy contour maps and energy surface maps were then generated by computer techniques. These maps indicate that repulsive forces are the major factor in regulating polypeptide chain folding, and yield a quantitative measure of stability for each conformation.

measure of stability for each conformation.
(Supported by the Center for Advanced Studies at the University of Virginia).

ELECTRON DIFFRACTION STUDIES OF TWINNING AND ITS RELATION TO THE ANTIFERROMAGNETIC SPIT DIRECTION IN THE NATURAL MINERAL HEATITE (&-Fe₂O₂). G. W. Franti. Dept. of Mats. Sci. UVA Charlottesville, Va. 22901

The antiferromagnetic structure of hematite has the electron spins along the c axis at temperatures below -10 $^{\circ}$ C. Above -10 $^{\circ}$ C, the spins are in the basal plane. This is the normal antiferromagnetic structure for hematite at room temperature.

In hematite crystals from Elba, the low-temperature phase is present at room temperature. Heating to 900°C causes the normal phase to appear. Subsequent heating to 1100°C results in the appearance of the low-temperature phase.

Twins in hematite were detected by electron diffraction. A twinned crystal corresponded to

Twins in hematite were detected by electron diffraction. A twinned crystal corresponded to the low-temperature phase whereas an untwinned crystal had the normal phase of the antiferromagnetic structure.

PRESSURE DEPENDENCE ON THE THERMAL CONDUCTIVITY OF TEFLON. R.B. Groome* and R.E. Barker, Jr., Dept. of Materials Science, Univ. of Virginia, Charlottesville, Virginia 22901

Polytetrafluoroethylene (Teflon), exhibits interesting phase transitions at temperatures slightly below and above room temperature. These transitions involve changes in the helical configuration of the molecules. The thermal conductivity K is very sensitive to changes in structure and it would be expected that an increase in order resulting from one of these transitions would result in an increase in K. However, PTFE exhibits some peculiar behavior with both increasing and decreasing values of K in the range of temperatures examined. By applying pressure up to 5Kbar and temperature up to 90°C we are attempting to characterize the dependence of K on pressure and temperature and to determine the physical origin of the transitions.

(Work initiated under NIDR Grant DE02111)

DETERMINATION OF FATIGUE DAMAGE AT STRESS RAISERS IN COMPOSITE MATERIALS. <u>E.G. Henneke</u> and K. Reifsnider, Department of Engineering Mechanics, VPI&SU, Blacksburg, Va. 24061

The heterogeneous nature of composite materials has a major effect on the development of fatigue damage, especially in the neighborhood of notches, holes, cracks, or other stress raisers. Fatigue damage modes which are common to monolithic materials, such as single flow propagation, are altered and frequently completely arrested by the material phase interfaces in composite specimens.

The present work reports the results of recent efforts to establish nondestructive testing techniques which can be used to identify and describe fatigue damage in boron-epoxy specimens using penetrating radiation and ultrasound.

USE OF DENSITY MEASUREMENTS TO STUDY THE THERMAL CONVERSION OF KYANITE TO MULLITE. <u>D. C. Jain</u> and J. J. Brown, Jr. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Density measurement was chosen as a tool to study the kinetics of kyanite to mullite conversion. The average density of kyanite was found to be 3.5410 gms/cc and of mullite after complete conversion (conversion being confirmed by x-ray diffraction, density and optical observations) to be 2.9855 gms/cc. Raw kyanite samples were heated for different lengths of time at 1200°C, 1250°C, 1300°C, 1350°C, and 1400°C, and degree of conversion was established from density measurements. There are two distinct stages in the course of transformation, the acceleratory period being dominated by the nucleation rate of the mullite phase and the deceleratory period by its growth rate, which is typical of a solid state reaction. The activation energy of the conversion in the acceleratory period was found to be 95.35 k cal. Exponential relationships are observed between time of complete conversion and temperature, and between rate of conversion and reciprocal temperature.

DIMENSIONAL GHANGE AND PORE DEVELOPMENT DURING HARDENING OF AG-SN AMALGAMS. <u>L. B. Johnson</u>, Jr., Dept. of Mat. Sci., Univ. of Va., Charlottesville, Va. 22901

Dimensional change during the setting of dental amalgam is one of the most important criteria for determining its usefulness. It was the purpose of this study to relate dimensional change to the fundamental structure changes.

Grystallographic data have been used to calculate the volumes of reactants and products in the amalgamation of Ag, Sn and Ag, Sn. These have been compared with direct volumetric measurements made with an electronic micrometer on compressed cylindrical specimens.

Results indicate that nearly all contraction is due to Hg going from the liquid to a solid phase. If all amalgamation products had enough mobility to fill all spaces previously occupied by Hg, all amalgams would show only contraction during setting. Any that do not show contraction, therefore, must develop pores. The amount of porosity can be calculated.

(Supported by NIH grant DE02111)

BULK MODULUS OF A MATERIAL CONTAINING VOIDS. R.A. Johnson, Dept. of Materials Science, Univ. of Virginia, Charlottesville, Va. 22901

The change in the effective bulk modulus of a material due to the porosity resulting from dispersed spherical voids, is determined using continuum elasticity theory. For the case of an isotropic elastic material under an applied hydrostatic pressure, the relative decrease in the bulk modulus is found to be of the order of three times the relative increase in volume of the material caused by the voids. (Supported by AEC Contract No. AT-(40-1)-3108 and the Center for Advanced Studies at the Univ. of Va.)

CORRELATION OF PROPERTIES OF ANHYDRIDE CURED EPOXY RESINS WITH STRUCTURE. R. E. Johnson* and A. L. Fricke, Dept. of Chem. Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Anhydride cured epoxy resins are used extensively in the chemical industry because of their good combination of cost and properties and are also often used in filament winding application because of their good high temperature properties. Unfortunately, little was known about their behavior upon aging. In this work, epoxidized novolac was cured with a wide range of types of anhydrides and properties determined as a function of aging temperature. Conclusions are drawn from the data with respect to the effect of anhydride structure on retention of properties upon aging. Appropriate additional work in progress is also discussed.

THE IDENTIFIGATION OF PHASES IN FRAGTURE SURFAGES OF DENTAL AMALGAM. G. I. Jones, Jr.* and H.G.F. Wilsdorf, Dept. of Materials Science, University of Va., Gharlottesville, Virginia 22901

Previous interpretations of scanning electron fractographs have been primarily dependent upon geometrical considerations of phases depicted. This study confirmed and explicated earlier descriptions. Samples of dental amalgam made by mixing mercury with spherical particles of Ag3Sn and subsequent pressing were used for diametral tensile tests. The resulting fracture surfaces were examined in the scanning electron microscope. Through the use of energy dispersive X-ray spectroscopy, relative compositions of the phases present were obtained. Evaluations of fractographs resulted in a new interpretation of fracture modes in this material.

Apparent matrix fracture areas, predominately γ_1 had at least four times the amount of mercury as the surfaces of alloy spheres, while the ratio of silver in the matrix to that on the spheres was less than 1:4; the tin content increased by a factor of about two from matrix to sphere surface. For any composition analysis in this study, the area scanned was about 0.25 square micron. With respect to sensitivity, elements present in amounts no greater than 3 wt % are easily detectable.

This research is supported by NIDR under Program/Project 5 TO1 DE 0015-08.

THE EFFECT OF LOCAL VARIATIONS IN YIELD STRENGTH ON CRACKS AND FATIGUE CRACK PROPAGATION RATES. M. $\frac{\text{Kahl}^*}{\text{Mechanics}}$, VPI&SU, Blacksburg, Va. 24061

The preponderance of existing literature which deals with plastic zones near crack tips considers materials and analyses in which the yield strength value is taken to be constant and uniform throughout the region under investigation, at least initially. Such an assumption is not easily defended if one is to consider crack initiation and propagation in real engineering components which may have been forged, cold worked, annealed, or cast during manufacture. The present work establishes analytically and experimentally the influence of one-dimensional gradients of yield strength on the size and shape of plastic zones in single edge notched (SEN) 7075-T6 aluminum specimens. The effect of such gradients on crack propagation rates is also examined.

THE EFFECT OF SOLUTE NITROGEN ON STRESS CORROSION CRACKING OF TYPE 304 STAINLESS STEEL WIRE. S. Maitra,* G. S. Clevinger, and J. L. Lytton, VPI&SU, Div. of Minerals Engr., Blacksburg, Va. $\overline{24061}$

The effect of varying solute nitrogen content on the stress-corrosion cracking behavior of type 304 0.025" diameter stainless steel wires has been determined for tensile stress levels of 20.2, 27.0, 33.7, 40.2, and 47.0 ksi. Time-to-failure was used as a measure of susceptibility. Three different nitrogen levels were studied: 0.033%, 0.059%, and 0.184%, and these were obtained by a combination of nitriding in nitrogen hydrogen gas mixtures and homogenization annealing.

The results revealed that the "knee" found by other investigators in plots of the logarithm of failure time vs. the applied stress was present at all three nitrogen levels and that the failure time decreased with increasing nitrogen content. The effect of nitrogen was found to be even greater for stresses well below the yield point than for stresses above it, suggesting that the effect of nitrogen is largely electrochemical rather than related to changes in dislocation structure. (Supported by AEC Contract No. AT-(40-1)-4052.)

THE ORDERING TRANSFORMATION OF EQUIATOMIC COPPER-PLATINUM. R. J. Mitchell, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901 and B. G. LeFevre, Sch. of Chemical Engineering, Ga. Inst. of Technology, Atlanta, Ga.

Samples of equiatemic copper-platinum were quenched from above the ordering temperature into icy brine, annealed at 300°C, 500°C and 700°C, and examined by microhardness, eptical microscope, electron microscope, and X-ray diffraction techniques. In samples annealed for short times at 300°C and 500°C, a fine-domained "mettled" structure centricular techniques. sisting of all four orientation variants of the ordered coll is seen. Continued annealing produces a coarse-demained grain boundary component which X-ray diffraction shows to have a higher degree of order than the mottled structure. At lower temperature the grain boundary component grows and replaces the mettled structure to complete the ordering transition. At high temperatures the mottled structures cearsen into order twins lying on [100] and [110] type planes. The transformation to order and the resulting hardness changes are seen to depend largely en the internal strains resulting from the cubic to rhembehedral distortion.

NON-LINEAR CONSTRAINED OPTIMIZATION OF POLYESTER-FILLER SYS-TEMS. V. K. Natarajan*, A. L. Fricke, and <u>J. A. Caskey</u>, Dept. of Chem. Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Polyester-filler systems are formulated to yield a suitable combination of properties for each application, preferably at the lowest possible cost. This typical formulation problem is an example of constrained optimization where the properties are the constraints. However, there are so many components in the average formulation that determination of the optimum is a complex problem. This work is a demonstration of a systematic and efficient method for handling such problems. An eight variable system was chosen, experiments were designed and run, and correlations were developed for each property constraint. Properties for several applications were specified and minimum cost formulations were calculated by a non-linear optimization method for each application.

HOLOGRAPHIC STRESS ANALYSIS. L.E. Parrish*, L.A. Marcus*, T.K. O'Brien*, and H.F. Brinson*. Dept. of Engineering Mechanics, VPI&SU, Blacksburg, Va. 24061

The use of holography as a stress analysis technique is described. Details of the apparatus and its arrangement are discussed as well as a simplified mathematical description of the optics necessary for stress analysis. Holograms of a beam in pure bending and a diametrically compressed disk are presented. Methods are described by which the isopachic fringes so generated are used in conjunction with photoelastic isochromatics to ascertain stress and strain distributions in the disk. Finally, the application of holography to other types of materials investigations is discussed.

POROSITY IN DENTAL AMALGAM CONTAINING GOLD. J.R. Parsons* and H.G.F. Wilsdorf, Dept. of Materials Science, Univ. of Va., Charlottesville, Va. 22901

A new spherical alloy (10% Au, 64% Ag, 26% Sn) has been shown to produce amalgams of improved strength and corrosion characteristics. During efforts to further improve this alloy, quantitative metallographic measurements were made to determine the average size and distribution of pores within the amalgam. Variables included condensation pressure (40,000 psi to 2000 psi) and a surface cleaning technique.

In all cases, results indicated the generally accepted pattern of decreasing porosity with increasing condensation pressure.

Average pore size and distribution was also

Average pore size and distribution was also affected by condensation pressure. The higher the packing pressure the smaller the number of pores, and average pore size. Notable was the fact that interconnecting pores were virtually eliminated in the samples compacted at high pressure.

Samples produced with "cleaned" alloy showed slightly greater porosity at all condensation

pressures. The average pore size was smaller and

the number of pores larger.
A brief comparison was made between amalgams containing Au and normal dental amalgam (Sponsored by NIDR, Program/Project DE02111)

A HIGH-GAIN LIGHT-INTENSIFYING DEVICE INCORPORATING A FIBER OPTIC X RAY INTENSIFYING FORCEPLATE. K.L. Reifsnider, Dept. of Engineering Mechanics, and J.J. Brown, Jr., Dept. of Metallurgical Engineering, VPI&SU, Blacksburg, Va. 24061

The results of initial attempts to apply a radically new concept to the development of an X-ray sensitive image intensifying device are reported. The new device consists of an X-ray sensitive fiber-optic faceplate which converts X-ray photons into visible light. The fiber-optic fluorescent plate replaces the powder fluorescent screen common to such techniques, with a subsequent improvement in resolution and in the percent of absorbed incident radiation. The resolution and X-ray stopping power of the fluorescent fiber-optic plate are not coupled as is the case for powder fluorescent screens. A resolution of 35 lp/mm is demonstrated in the present work.

THE EFFECT OF ELEVATED TEMPERATURES ON DENTAL ALLOYS. C. L. Reynolds* and F. E. Wawner, Dept. of Materials Science, University of Virginia, Charlottesville, Virginia 22901

The influence of elevated temperatures on dental alloys is of considerable interest to dental technology particularly the phase changes that occur.

Considerable difference was noted in the phases containonsiderable difference was noted in the phases containing Hg obtained by two different preparation techniques. All of the alloy samples that were subjected to heat and pressure readily lost Hg with a maximum of 23% occurring in the sample that contained 13 wt % Sn. The Sn containing alloy sample that containing alray transformed to the $\beta_1(Ag-Hg)$ phase in a $\gamma_1(Ag-Hg)$ matrix. There was no evidence of the $\gamma_2(Sn-Hg)$ phase in any of the samples indicating that by the use of pressure the Sn atoms can be accommodated into the β_1 and γ_1 lattices. Samples that were heated at atmospheric pressure lost virtually no that were heated at atmospheric pressure lost virtually no Hg and in general were composed of β_1, γ_1 , and γ_2 . The amount of γ_2 was seen to increase with higher Sn content until at 26 wt % Sn, the alloy consisted solely of β_1 and γ_2 . The fact that no wt. loss was observed implies that Hg liberated by the γ_1 decomposition is not given off by the sample as free Hg but reacts with excess Ag₃Sn to force a self perretuating reaction self perpetuating reaction.

TIN OXIDE FILMS DEPOSITED BY A SPRAYING TECHNIQUE.
A. Rohatgi* and L. H. Slack. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A technique for the deposition of conducting transparent thin films on plate glass has been refined. The technique consists of spraying an alcoholic solution of SnCl_4 onto the heated glass. The effects of spray rate, temperature of the substrate and other sensitive technique variables will be described.

The films have a colored tint due to optical diffraction, and the films are usually noncrystalline. Methods currently being used to determine the film's composition and structure are described. (Aided by a grant from ASG Industries.)

THE APPLICATION OF TOPOLOGICAL CONCEPTS IN STEREOLOGY.

J. H. Steele, Jr. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The quantitative characterization of microstructure involves consideration of the topological properties of the physically distinquishable 3-dimensional regions (e.g. phases of grains) which constitute it. The two topological properties of primary interest are the connectivity and number of separate regions. These two properties do not provide a topological classification for the 3-dimensional microstructure; however, they do provide a basis for quantitative comparison of the extent of continuity (or interconnectedness) among phase regions. The connectivity of a single 3-dimensional region may be defined in terms of the number of closed curves which can be constructed within it that cannot be continuously deformed into one another or into a point without penetrating the closed bounding surfaces of the region. This property and the number of separate regions can be measured using a serial sectioning technique.

The application of these concepts and equations to sintering and porous bodies and to characterization of normal grain growth will be presented.

TENSILE FRACTURE OF UNIDIRECTIONAL B-AL COMPOSITE. J. H. Steele, Jr. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061, and H. W. Herring, NASA, Langley Res. Ctr., Hampton, Va. 23602

Fracture in unidirectional boron filament-aluminum matrix composite under axial tension was studied using scanning electron microscopy, microradiography, and an acoustic emission technique. The combination of these analysis techniques has allowed the description and microstructural characterization of a new non-cumulative fracture mode which involves filament break propagation. The fracture mode was found to severely limit the tensile strength of the composite since its initiation leads to catastrophic failure at filament stress levels above a critical value. The critical filament stress was found to be 170,000 psi, apparently independent of filament diameter, number of filament layers, and the type of matrix alloy. A comprehensive analysis of fracture surfaces indicated several different characteristics, the most prominent of which was the fragmentation of the filaments to form wedge-like sections indicating the direction of break propagation. Matrix fracture was characterized by ductile rupture which occurred after filament failure. It was found using filament strength distributions that the initiation of break propagation occurs when a filament fails above the critical stress. Thus the weakest filaments in the strength distribution appear to control the ultimate strength when filament stresses exceed the critical

MATHEMATICAL ANALYSIS OF THE HIGH TEMPERATURE OXIDATION OF TD-NiCr. D. R. Tenney and A. V. Pawar; VPI&SU, Div. of Minerals Engineering, Blacksburg, Va. 24061

of Minerals Engineering, Blacksburg, Va. 24061
In the TD-NiCr system a volatile CrO₃ phase is formed at a significant rate for all temperatures above about 900°C. A correction for the loss of Cr by the formation of CrO3 must be made to weight gain oxidation data for this alloy before the data can be used by the design engineer to estimate service life. A theoretical analysis of the total oxidation process of this alloy which makes such a correction possible has been developed. A total mass balance approach has been used which makes use of the rates of diffusion in the alloy and oxide phases, rate of dissociation of NiO, kinetics of $NiCr_2O_4$ formation, rate of CrO_3 volatilization, and reported weight gain data to treat the problem of a moving metal/oxide interface. The analysis calculates the time dependence of the oxide thickness, loss of Cr by formation of ${\rm Cr0}_3$, and the decrease of substrate thickness for given oxidation conditions. Also, by employing the Murray-Landis variable grid technique, the appropriate diffusion equations have been solved to calculate the extent of Cr depletion in the alloy substrate as a result of the selective oxidation of Cr. (Aided by NASA Grant NGR-47-004-082.)

X-RAY DIFFRACTION INVESTIGATION OF BIMETALLIC DIFFUSION ZONES IN THE Cu-Pd SYSTEM. D. R. Tenney, Division of Minerals Engr., Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061, P. K. Talty, Airforce Mat'ls. Research Lab., Wright-Patterson Air Force Base.

The recent development of new x-ray diffraction techniques has made it possible to determine both the composition profile and the atomic arrangements associated with small diffusion zones. These techniques have been employed to investigate the diffusion of 10μ thick deposits of Pd into [100] oriented single crystals of Cu. The concentration profiles produced by isothermal diffusion at 900°C were determined by mathematical analysis of two diffracted intensity bands. The Boltzmann-Matano analysis was used to extract concentration dependent diffusion coefficients which were found to compare favorably with previously reported values. Also, x-ray rocking curves were made at selected compositions to determine the degree of diffusion-generated subgrain misorientation increase in the diffusion zones. These rocking curves were Gaussian in shape and indicated that the distribution of subgrain misorientations was Gaussian. The widths of the Gaussian misorientation functions were found to be related to the lattice parameter gradient existing in the specimen after diffusion. The results of this investigation are compared with those obtained from a previous examination of nearly identically prepared Cu-Ni specimens. (Aided by NSF Grant NSF-GK-5731.)

INVESTIGATION OF THE OXIDATION BEHAVIOR OF DISPERSION-STABILIZED ALLOYS WHEN EXPOSED TO A DYNAMIC HIGH TEMPERATURE ENVIRONMENT. D. R. Tenney and C. T. Young, VPI&SU, Div. of Minerals Engr., Blacksburg, $\overline{\text{Va.}}$ 24061, and H. W. Herring, NASA, Langley Res. Ctr., Hampton, Va. 23602

The oxidation behavior of TD-NiCr has been studied in static and high speed flowing air environments at 2000 and 2200°F. Scanning electron microscopy, x-ray diffraction, and electron microprobe techniques have been employed to characterize the oxides and oxide morphologies formed on this alloy as a function of surface preparation, exposure time, and specific oxidation conditions in both types of environments. Surface preparation was found to affect the order, relative amount, and morphology of oxides formed. An adherent, dark green layer of Cr203 was observed on specimens prepared by grinding or diamond polishing. However, on specimens electropolished before oxidation, the primary oxide formed was NiO.

The stable oxide morphologies formed on the specimens exposed to the static and dynamic environments were markedly different. The facited crystal morphology characteristic of static environments was found to be very unstable under high temperature high speed flow conditions and rapidly transformed to a porous "mushroom" type structure. The mushroom type oxide growths were very friable and easily broken from the surface. These mushrooms, usually NiO, were connected to the alloy substrate or in some cases to a continuous inner oxide layer by solid oxide grains.

QUANTITATIVE ENERGY DISPERSIVE X-RAY SPECTROSCOPY. R.L. $\underline{\text{Trent}}^*$ and W.A. Jesser, Department of Materials Science, University of Virginia, Charlottesville, Virginia 22901

Experimental investigations using an energy dispersive x-ray spectrometer in conjunction with a Siemens 120 kV transmission electron microscope have been carried out on a quantitative basis which required certain modifications of the system as well as extensive calibration techniques.

Experiments were carried out at accelerating voltages between 40 and 120 kV; however, above 40 kV a substantial increase in background radiation was noted due to an increased number of backscattered electrons entering the x-ray detector. The background contribution from these electrons was eliminated by inserting a magnet between the microscope and the detector. With this modification essentially equivalent spectra can be obtained at all accelerating voltages.

The calibration techniques consisted of standardizing the incident electron beam with a known specimen as well as determining the correction factor for peak height as a function of total countrate.

The system was used to measure film thickness for the case of silver overlays on gold substrate films. The apparent increased thickness of the overlay was determined for a range of substrate thicknesses. We gratefully acknowledge the support of Atomic Energy Commission Contract No. AT (40-1) - 3108.

THE INFLUENCE OF MECHANICAL STRAIN ON DIFFUSION AND PERMEATION IN POLYMERS. R.C. Tsai* and R.E. Barker, Jr., Dept. of Materials Science, Univ. of Virginia, Charlottesville, Va. 22901

The effect of mechanical strain on the diffusion and permeation of 0_2 , N_2 , C0, CH_4 , and Ar in acrylic polymers and copolymers has been studied. Because mechanical strain increases the statistical order of the polymer chains, there is an improvement in the efficiency of van der Waals bonding between groups on adjacent polymer chains and the configurational entropy is thus decreased. Therefore for each diffusional step to occur, an additional local disorder must be achieved. The increase in the activation entropy for diffusion ΔS^* corresponds to the decrease in the configurational entropy $-\Delta S_{\rm C}$. An analysis of the experimental data in terms

An analysis of the experimental data in terms of the theory of activated rate processes supports our previous hypothesis of the correlation of ΔS^* and ΔS_C and also is in accord with a model that explains the increase in the activation enthalpy

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A NON-DESTRUCTIVE X-RAY TECHNIQUE FOR STUDYING GRAIN BOUNDARY DIFFUSION. J. Unnam* and C. R. Houska, Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A generalized two-dimensional diffusion model has been developed which consists of an array of boundaries coupled to the free surface and to the substrate lattice. The model makes use of three nonlinear partial differential equations which describe lattice, grain boundary, and surface diffusion. This two dimensional model has been programmed for the IBM 360 computer using a finite difference solution to give concentrations as a function of time.

An x-ray intensity simulation program is developed to give integrated diffracted intensity for a given concentration distribution. This simulated intensity is compared with experimental intensity. Data are presented from a sample containing 8 microns of Ni on a (111) oriented Cu crystal diffused for various times at 900°C and a similar sample with 6.5 microns of Ni diffused at 600°C. The simulations are in good agreement with experimental intensity bands.

are in good agreement with experimental intensity bands. Activation energies and $D_{\rm O}$ values are calculated for lattice diffusion. The lattice activation energies are in excellent agreement with melting point correlation; namely, $Q=38\ T_{\rm m}$. Activation energies and $D_{\rm O}$ values are also calculated for grain boundary diffusion. These are in good agreement with the existing literature values.

OBSERVATIONS ON THE GROWTH OF GRAPHITE WHISKERS. F. E. Wawner, Jr., Department of Materials Science School of Engineering & Applied Science, Charlottesville, Virginia 22901

A study has been conducted to show the dependency of the growth of graphite whiskers on a metallic impurity. It was seen that heating carbon monofilament by striking a dc arc utilizing a tungsten electrode in a gaseous environment of Ar, N_2 and HCl led to growth of graphite whiskers. If the tungsten electrode was replaced by a carbon one, whisker growth was not observed. Repeating these experiments after removing HCl from the gaseous environment showed no whisker growth in either case.

It is purposed that the growth of the whiskers can be attributed to the HCl reacting with the tungsten to form WCl $_6$ which is reduced to tungsten on the carbon substrate serving as an impurity site. The morphology of the observed whiskers suggests that growth proceeds by Wagner's VLS mechanism for whisker growth.

PHASE SEPARATION SPINNING OF POLYPROPYLENE. M. C. Williams* and $\underline{A.\ L.\ Fricke}$, Dept. of Chem. Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

Phase separation spinning, a variation of solution spinning in which a high boiling solvent is used so that, upon spinning, the polymer and solvent separate but the solvent does not evaporate, has been applied to the polypropylenenaphthalene system. Results for this system demonstrate that the technique offers the advantages of spinning at low temperatures with large diameter spinnerets to make small denier fibers, of high spinning speeds, and of imparting unusual structure to the fiber. Fibers made in this study were porous, possessed helical crimp in some cases, and exhibited good tenacity after only moderate drawing treatment.

CHARACTERIZATION OF BICRYSTALS USING KIKUCHI PATTERNS. C. T. Young, J. H. Steele, Jr., and J. L. Lytton. Div. of Minerals Engineering, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Three parameters, the misorientation angle, misorientation axis, and boundary normal, have been used to describe a general bicrystal, such as two adjacent grains, subgrains, or twins. An analysis has been developed to determine these parameters. The angle and axis of misorientation are calculated from a misorientation matrix obtained from two Kikuchi patterns, one taken from each of the two crystals. To obtain the boundary normal, a specimen tilt is made inside the electron microscope. A rotation matrix specifying the actual specimen tilt is formulated from two Kikuchi patterns taken from the same crystal before and after tilt. With this rotation matrix and the change of projected boundary images before and after tilt, the boundary normal can be calculated. It has been demonstrated that for high-angle bicrystals, the misorientation angle may be determined to within \pm 0.2°, and the misorientation axis to within 0.1°. For low-angle bicrystals, the misfit angle can be obtained to within $\pm~0.1^\circ$, and the misfit axis to within 4° . The boundary normals so determined are generally accurate to 2° if suitable correction is made for the magnification change resulting from the specimen tilt. Calibration curves for the correction of errors in magnification and camera length, which result from the shifting of specimen along the electron-optical axis, were obtained.

Section of Medical Sciences

Fiftieth Annual Meeting of The Virginia Academy of Science May 3–5, 1972, Lexington, Virginia

ANALYSIS OF METHYL GLYOXAL. R. B. Brandt and M. J. Black*. Dept. of Biochem., Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219

Methyl glyoxal (MeG) has been implicated in mammalian systems and bacteria as a source of lactic acid, as a metabolite of glycine via amino acetone formation, and most importantly as an inhibitor of growth. It is a substrate for the combined enzyme system glyoxalase I and glyoxalase II with glutathione as a cofactor for the production of D-lactate.

A number of assay systems have been described for methyl glyoxal including the enzymic formation and spectrophotometric measurement of glutathione-methyl glyoxal, the manometric measurement of ${\rm CO}_2$ from the catalyzed formation of lactate, a titrimetric method and more recently spectrophotometric measurement of the methyl glyoxal disemicarbazone.

A method was developed for the routine assay of MeG and is as follows: 4.0 ml of an ethanolic-HCl (10 ml of conc. HCl/250 ml of abs. EtOH) solution containing 8 x 10-7 moles of 2,4-dinitrophenylhydrazine was incubated at 42° for 70 min. with 0.05 ml samples of aqueous solutions of purified MeG ranging from 0.8 to 4 x 10-8 moles. The absorbance was measured at 432 nm. Standard curves indicate reproducibility for the pure system. (Supported in part by A. D. Williams Funds.)

DIURNAL VARIATION IN DNA SYNTHESIS IN HAMSTER CORNEAL EPITHELIUM AND CONDYLAR CARTILAGE. George W. Burke, Marshall C. England, Jr., and Frank M. Dolwick. School of Dentistry, Richmond, Virginia 23219

Twenty-four adult male hamsters were administered in-

traperitoneal injections of tritiated thymidine (specific activity 1.9 curies/millimol) at a dose rate of 1 microcurie per milligram of body weight. Groups of 4 hamsters were injected at 4 hour intervals for a period of 24 hours. Animals were killed one hour following injection and eyes and condyles were removed and placed in NBF for fixation. Following this procedure the corneas were dissected from each eye and bone was trimmed from each condylar head back to junction with the condylar cartilage. All samples of tissue were allowed to air dry and weighed to the nearest hundredth of a milligram. All corneas (3) for each time interval were placed in a glass vial designed for scintillation studies and digested in 1/2 ml of NCS (Nuclear of Chicago Solubilizer) using a heated water bath. Pooled samples of condyles (3) were similarly treated. A standard liquid scintillation solution (Aquasol) was added to each vial (15 ml) and the samples of digested tissues were monitored for radioactivity in a refrigerated scintillation spectrometer. Counts per minute per milligram (CPM/mg) were calculated and plotted against time. Both corneas and condylar cartilages exhibited a diurnal rhythm in DNA synthesis. The curves expressing variable activity were similar to those obtained from samples of oral mucosa from both rats and hamsters.

Glomerular Ultrastructure of Preserved Kidneys. Shirley S. Craig; Hugo R. Seibel and Richard J. Weymouth, Department of Anatomy, VCU- Medical College of Virginia.

Glomeruli of eight canine kidneys were studied by light and electron microscopy to determine if significant structural alterations occur during 24 hours of hypothermic pulsatile perfusion. The kidneys were subsequently autografted and contralateral nephrectomy was performed at that time. Biopsies of these kidneys were taken at nephrectomy, after 24 hours preservation and at one hour post-

Profound glomerular changes were observed in all cases; the changes were observed in all cell types but were more severe in the endothelial cells. The basement membrane was edematous and thickened in four cases. At one hour postanastomosis the glomerular structural appearance was greatly improved.

BUN, serum creatinine and the ability of the kidney to sustain the life of the recipient were used as criteria for determining the viability of the preserved kidney. BUN and serum creatinine returned to a normal range in five dogs. The physiologic tests and survival attest to the functional capacity of the preserved kidneys. Study of tissue samples at autopsy indicated that although some structural changes persisted, some of the alterations were reversible.

We gratefully acknowledge the surgical procedures that were carried out by Dr. George Abouna.

WHAT IS NORMAL BIOCHEMISTRY FOR THE BLOOD AND URINE OF PRE-SCHOOL CHILDREN IN SOUTHERN TUNISIA ON A HIGH CARBOHYDRATE DIET? S. Gamble and Z. Kallal*, Chem. Dept. Lynchburg College, Lynchburg, Va. 24504 and Inst. of Nutrition, Tunis, Tunisia.

Three thousand pre-school children in southern Tunisia comprise a sample population that is being examined to test the effectiveness of supplementing wheat with the amino acid, lysine. This paper is concerned with the baseline biochemical data of the target group. The measurements included determinations of hematocrit, hemoglobin, plasma protein, serum albumin, alkaline phosphatase, urinary riboflavin and creatinine. Parasites are considered as a variable, and in particular, Shistosoma haematobium, which was monitored throughout the study. The data may add to the parameters of nutritional studies of pre-school children on a low protein caloric intake. (Sponsored by Dept. of Nutrition, Harvard Univ. and AID)

MICROCAPSULE SUSPENSIONS AS WHOLE-BLOOD MODELS. Barry
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With interest in the use of artificial organs and circulatory assist devices increasing, the need of a model blood for use in design studies is accentuated. Attempts to develop such a model using microcapsule suspensions have been made at the University of Virginia. Various oils have been encapsulated with gelatin as the wall material by a simple coacervation process. Capsules ranging in size from 20 to 1000 microns have been produced in this manner. Flow through rigid and distensible tubing have been carried out to ascertain the usefulness of capsule suspensions as blood models.

In light of recent whole-blood studies, it has been shown that the diformability of red cells and their tendency to aggregate are key determinants of the gross rheological properties of whole blood. It is felt that flow of the suspension through small tubes, only a few times the capsule diameter, will offer further insight into the effectiveness of the model. These data will be discussed in light of the new work in the field of blood rheology.

HOW TIGHT ARE THE "TIGHT JUNCTIONS" IN THE EPIDERMIS OF FROG SKIN? James H. Martin, Hugh R. Seibel, and Ernst G. Huf. Dept. of Physiology, Med. Col. of Va., Richmond, Va. 23219

In the past few years, several authors have suggested that the site for transepithelial transport might be via the intercellular spaces through the so-called "tight junctions" These tight junctions would act as gates, opening and closing to control the flow. They may be selective by virtue of charge, carrier molecules, or some other mechanism. If the tight junctions indeed have the ability to open and close, then it was reasoned that at some hydrostatic pressure, or combination of pressure and chemical modifier, the channels could be opened wide enough to observe an ultrastructural change and flow of electrolytes and stains across the epithelium. Differential pressures up to 1 atmosphere were applied to frog skin in either the inward or outward direction. Fluid flow completely stopped when pressure (>100 mm Hg) was applied to the outer surface (corium) and was essentially linear with applied pressure when pressure was applied to the inner surface $(0.70 \times 10^{-10} \text{ cm}^{-3}/\text{dyne-sec})$. Ultrastructural data indicate that bulk flow occurs across the cells in the cornified layer and that these cells offer considerable resistance to flow. The pathway between the subcorneal space and the intercellular spaces is yet undetermined. The data indicate that discrete pores are involved, but whether the pores occur in the outer membranes of the first reacting cells or in the tight junctions is unknown. (Supported by A. D. Williams Fund 3558-538)

THE PRESENCE OF DECAPACITATION FACTOR IN CAT SEMINAL PLASMA. Keith C. McLaughlin and C. E. Hamner. Dept. of Biology and Dept. of Obstetrics and Gynecology, Univ. of Va., Charlottesville, Va. 22901.

The presence of a naturally occurring fertilization inhibitor (decapacitation factor, DF) in the seminal plasma of several species has been established. In these preliminary experiments, cat seminal plasma has also been shown to exhibit DF activity. The assay for DF used was the ability of cat seminal plasma to inhibit the fertilizing capacity of uterine capacitated rabbit sperm (Chang, 1957, Nature 179: 258). Fresh, untreated cat seminal plasma completely inhibits fertilization by capacitated rabbit sperm. DF activity can be progressively attenuated by diluting the cat seminal plasma to 2 to 3 times its original volume. Dilutions greater than these render DF undetectable by this assay. Cat DF activity is reduced by heating the seminal plasma to 100°C for 10 minutes, but heating to 60°C for 10 minutes has no effect. The fact that cat seminal plasma does not permanently destroy the fertilizing capacity of rabbit sperm is shown since the sperm regain the ability to fertilize eggs when re-incubated in the uterus for 6 to 8 hr. after treatment. These results indicate that cat DF exists, is concentration dependent, and is partially heat labile.

AN ULTRASTRUCTURAL STUDY OF SECRETION IN THE RABBIT OVIDUCT. <u>Joan C. Lambert</u> and C. E. Hamner Dept. of Biology and Dept. of Obstetrics and Gynecology, University Virginia, Charlottesville, Va. 22901.

A morphological study of the epithelium which lines the rabbit oviduct indicate the presence of two principal cell types: ciliated cells and non-ciliated secretory cells.

At estrous, the secretory cells are characterized by the presence of numerous electron dense secretion granules, a widely expanded RER and a prominent Golgi complex. Immediately after ovulation however, many cytological changes occur which suggest a discharge of this secretory material into the oviduct lumen. These changes, which include a massing of the secretion granules toward the cell apex and a bulging of the apical portion of the cell into the oviduct lumen, occur at the time in which the early cleavage stages are passing through the oviduct.

The changes in the appearance of the secretory cells during the reproductive cycle suggest that their function is controlled by the ovarian hormones. Observations of the rabbit oviduct which had been ovariectomized 21 days and supplemented with estrogen and/or Progesterone demonstrated that estrogen is necessary for the synthesis of the secretory material while progesterone function is to enhance the release of the secretion.

STEADY-STATE LEVELS OF GLYCOLYTIC INTERMEDIATES OF NORMAL AND HYPOPHYSECTOMIZED RATS, <u>W.R. McConnell</u>* and J.P. Liberti, Dept. of Biochemistry, Health Sciences Div., Va. Commonwealth University, Richmond, Va. 23219

Although hypophysectomy (Hx) affects carbohydrate metabolism dramatically, the causes are not well understood. In order to gain some insight regarding the mechanism by which Hx manifests these changes, the levels of glycolytic intermediates from livers of normal and Hx rats were measured. As an indication of lipid, glycogen, and pentose shunt metabolism; Ac-CoA, glycogen, and 6-P-gluconate were measured respectively. Hx increased the steady-state level of gluc.-6-P 34% and fruc.-6-P 39% whereas 6-P-gluconate and Ac-CoA decreased 40% and 18% respectively. The greatest increase, 300%, was observed in the levels of glyceraldehyde-3-P.

The elevation of glyceraldehyde-3-P may be due to (1) an inhibition or reduced synthesis of glyceraldehyde-3-P DH and/or phosphoglycerate kinase and (2) a decreased NAD+/NADH ratio. In addition, elevated levels of gluc.-6-P and fruc.-6-P could arise by inhibition of phosphofructokinase. The data presented show that Hx elicits changes in the levels of glycolytic intermediates which are consistent with a diminished rate of glycolysis. These data indicate that Hx may affect certain key regulatory enzymes of glycolysis.

BLOOD PLASMA OXIDATION-REDUCTION POTENTIAL, PROTEIN AND CORTICOSTERONE LEVELS IN PROTEIN DEFICIENT RATS. M. U. K. Mgbodile*a and <u>G. Colmano</u>. Dept. of Veterinary Science, VPI & SU, Blacksburg, Va. 24061

Twenty-one day old male rats were divided into 2 groups and pair-fed for 15 days either a 5% or 20% casein diet. The protein deficient diet resulted in a severe retardation of growth as shown by a 12-15% gain compared to a 50-70% gain in body weight by the 20% group. This observation is consistent with the reported data of Mgbodile et al (Fed. Proc., 31:729, 1972) that dietary protein insufficiency lowers both the liver cell DNA and microsomal protein concentrations. Protein starvation induced a response comparable to stress as shown by an 89% increase in the plasma corticosterone concentration. 26% decrease in the blood plasma protein concentration in the 5% group correlated with a similar decrease in the availability of ceruloplasmin and with a higher oxidation-reduction potential expressed on a mg of plasma protein basis. A decreased ceruloplasmin level caused by protein deficiency is reflected in a decreased ACTH production in response to stressful situations (Rowan and Colmano, Va.J.Sci., 21:148,1970). Clinical applications are feasible by substituting the measurements of ceruloplasmin for ACTH and of oxidation-reduction potential for corticosterone. These clinical applications will facilitate further studies of some responses to stress mechanisms, which in this presentation are related to nutritional protein deficiencies.

aGraduate student, Dept. of Biochemistry and Nutrition.

PROCEDURES FOR THE ISOLATION OF PATHOGENIC NAEGLERIA. E. Clifford Nelson. Dept. of Microbiology, Va. Commonwealth Univ., Richmond, Va. 23219

Primary amoebic meningoencephalitis is a highly fatal human disease caused by infection with a species of Naegleria Isolation from a fatal case in Virginia was accomplished in 1967. Since then a year around program to devise a method of detecting the pathogen in nature has been in progress. The routine procedure has been to grow out Naegleria-like amoebae by selective cultivation from environmental sources. To detect invasive pathogenic strains mice are inoculated by intranasal instillation of culture suspension.

In late summer 1971 the first detection of a pathogenic strain was accomplished. By this date we had tested a total of 226 strains obtained from 13 lakes and ponds, 4 streams,

the James River, 2 springs, 3 soil samples, 2 sewage lagoons and 34 coprozoic strains from animals.

The strain was one of 14 isolated and tested from a small pond not used for swimming. In the mouse, illness develops in about a week with evidence of mid brain or hind brain involvement. This strain may prove to be a bridge between the devastating pathogen isolated from human cases and the harmless or swarming in water. The degree of pathogenicity for man is conjectural but this type of strain should be considered in insidious forms of middle and inner ear and hind brain involvement.

A NEW TECHNIQUE FOR STAINING MITES. J. Clark Osborne and D. F. Watson. Dept. of Veterinary Science, VPI & SU, Blacksburg, Va. 24061.

Developing stages and adult mites are not readily visualized in many preparations due to lack of contrast and low light refractiveness. A new staining method was accidentally achieved when it was found that red nail lacquer used to seal the coverglass on a fresh lacto-phenol preparation slowly diffused into the solution and gave a light pink stain to the mites. This particular lacquer contained three pigments dispersed in a nitrocellulose lacquer base, an alcohol soluble approved dye, dissolved in isopropyl alcohol and anatase titantium dioxide in a nitrocellulose base. Small droplets of the red nail lacquer were added directly into the lacto-phenol from a drawn out capillary pipette with good staining results. The Red No. 19 (Rhodamine B) 3-ethochloride of 9-o-carbonyphenyl-6-diethylamino-3-ethylimino-3-isoxanthene in isopropyl alcohol (Lacquerite Division of SUPRONICS CORPORATION, Livingston, New Jersey 07039) gave satisfactory, but not superior staining results on the

NEUROMORPHOLOGICAL REASONS FOR LESSER PAIN SENSI-

NEUROMORPHOLOGICAL REASONS FOR LESSER PAIN SENSI-TIVITY IN PRIMARY TEETH. C. Pratt and U. Karlsson *. Dept. of Biology, VPI & SU, Blacksburg, Va. 24061, and Univ. of Iowa, Iowa City, Iowa 52240. Clinical experience suggests that primary teeth are less pain sensitive than permanent teeth. As a preliminary step to disclose the an-atomical basis for this difference, transverse apical sections from barely erupted and fully e-rupted primary tooth pulps were examined by light rupted primary tooth pulps were examined by light and electron microscopic technics. Glutaraldehyde and osmium fixation was followed by Vestopal Wembedding. Results from beagles, pigs, and humans were compared with data from permanent teeth in marmosets and from the literature.

Several structural differences were noted. Contrasting differences for primary teeth were:

1) Total number of nerve fibers were higher, 2)
Relative number of unmyelinated fibers were higher, 3) Myelinating fibers were common, 4) Myelin sheaths generally appeared thinner and 5) There were relatively fewer nerve structures in the

zone of Weil.

These qualitative results were all interpreted to be consistent with lesser somatic sensitivity in the primary tooth. The inference is that neuromorphological parameters in the tooth are amenable to perception difference questions.

EFFECTS OF AMINES ON THE HYDROLYSIS OF ESTERS BY TWO ENZYMES THAT ARE ESSENTIAL FOR BLOOD CLOTTING. P.S.Roberts, R.M. Ottenbrite and P.B.Fleming*. Div. of Med. Oncology, Dept. of Medicine, Med.Col.of Va. and Dept. of Chemistry and Pharma-ceutical Chemistry, Va.Commonwealth Univ., Richmond, Va.23219.

Choline chloride has no effect on the hydrolysis of esters by thrombin but it accelerates the hydrolysis of TAME (ptoluenesulfonyl-L-arginine methyl ester) and inhibits the hydrolysis of BAME (benzoyl-L-arginine methyl ester) by thrombokinase, the activated form of blood clotting Factor X that converts prothrombin to thrombin. Ethanolamine, CH3NH2 and (CH3)2NH have no significant effects on ester hydrolysis by either enzyme but (CH3)3N weakly accelerates the thrombokinase-TAME reaction. Quaternary amines, however, accelerate TAME and inhibit BAME hydrolysis by both enzymes. Choline chloride, (CH3)4NBr and (n.propy1)4NBr produce about the same acceleration of the thrombokinase-TAME rates, but (ethyl)4NBr is a much more and (n.butyl)4NBr is a slightly more potent accelerator. While the thrombin-TAME reaction is unaffected by (CH₃)4NBr, it is accelerated by the other quaternary amines and the thrombin-BAME reaction is inhibited by them. Kinetic studies show that (ethyl)4NBr is a competitive inhibitor of the thrombokinase-BAME reaction but its acceleratory effects on the reaction with TAME are complex. Quaternary amines, therefore, react with the enzymes to inhibit their action but a step during the hydrolysis of TAME is probably accelerated by these cations. (Supported by USPHS Grant HE-13379.)

SOLUBILITY STUDIES ON TOTAL RAT ANTERIOR PITUITARY PROTEIN, GROWTH HORMONE (GH) AND PROLACTIN (P1) LABELED IN AN $\overline{\text{IN}}$ VITRO INCUBATION. Marcqueta H. Samli, Dept. of Biochemistry and Nutrition, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

The particulate-associated nature of a significant proportion of the rat pituitary protein labeled in an $\frac{in}{a}$ vitro incubation was demonstrated. After incubation with a $^3\mathrm{H-}$ amino acid mixture pituitaries were homogenized, the homogenates made 0.25 M in sucrose and centrifuged at 10,000 or 105,000 g. Amount of labeled protein in homogenate supernates was determined and compared to non-centrifuged controls. After homogenization in Krebs-Ringer Bicarbonate (KRB) or neutral saline, less than half of the total labeled protein was found in homogenate supernates after a 10-min 10,000 g centrifugation whereas after homogenization in, e.g., 1 mM EDTA or 0.1% sodium dodecylsulfate (SDS), 90-100% of the labeled protein was in the supernates. Of the media tested only 1% SDS was capable of completely solubilizing labeled protein as determined after centrifugation at 105,000 g for 2 hr. Hormonal protein was included in the labeled protein sedimented during centrifugation. The total label recovered in GH and Pl, as determined after separation of these hormones by polyacrylamide gel electrophoresis, was much decreased after centrifugation at 10,000 g when homogenization was in neutral saline, water or KRB. Conversely, little decrease was noted for EDTA homogenized pituitaries. (Aided by NIH Grant 1 RO1 AM 13776.)

PRELIMINARY REPORT OF CYSTINURIA IN AN INBRED AMERICAN INDIAN ISOLATE. M. J. V. Smith*, J. I. Townsend, and W. L. Banks, Jr. Div. of Urol., Program in Human Genetics, and Dept. of Biochem., Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219 Univ., Richmond, Va. 23219
Cystinuria, which has previously been reported only in

Caucasians, has now been diagnosed in 16 Chickahominy Indians of Charles City County, Virginia, and confirmed by amino acid analysis in four of these individuals, all belonging to a large, extended kinship, which is characterized by moderate inbreeding. This is the largest kinship in which cystinuria has yet been studied. tentative pedigree that includes 155 members of the kinship has been constructed. Investigations are being continued to discover whether or not the autosomal gene that apparently determines the trait is completely recessive in this (Supported in part by an A. D. Williams Research isolate.

ANTIFERTILITY EFFECTS OF EXTRACTS FROM SPECIES OF MOMORDICA. W. Stepka, G. E. Madge* and K. Wilson* Dept. of Pharmacy and Dept. of Pathology, Med. Col. of Va., V.C.U., of Richmond, Va. 23219

Young female mice of proven fertility, dosed daily with juice expressed from fresh leaves of Momordica, show a significant reduction in fertility compared to controls dosed with saline. M. balsamina appeared to be somewhat more effective than M. charantia. In a typical paired group experiment 91% of the controls delivered litters whereas only 18% of treated females did so. Litters delivered by the latter were normal in number and the pups showed no gross abnormalities.

Various experimental designs were used in attempts to elucidate the mechanism of action. Although we succeeded in producing abortions with the drug, these are uncommon. Our data do not permit us to distinguish among such possibilities as prevention of conception or of implantation, or of early resorption, as the major mechanism.

We looked for, but could not find, a residual effect on the fertility of experimental females in subsequent matings without drug,

This investigation was supported in part by General Research Support Grant FR-5697-02 from the General Research Support Branch, Division of Research Facilities and Resources, National Institutes of Health.

PATHOLOGICAL AND HISTOLOGICAL OBSERVATIONS ON FEMALE MICE TREATED WITH EXTRACTS OF MOMORDICA. Kendall Wilson, Jr.*, Gordon E. Madge*, and William Stepka. Dept. of Pathology and Dept. of Pharmacy, Med. Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219

Young female mice of proven fertility were subjected to daily oral doses of juice expressed from the leaves of M. balsamina beginning on day one of pregnancy. Previous work indicated this to be an abortive agent. In the present series we succeeded in producing abortions 5-11 days after mating which were preceded by vaginal bleeding. Some of the animals were sacrificed at the first sign of vaginal bleeding and organs placed in 10% formalin. Tissues were processed for sectioning and stained with H & E. No pathological changes were seen in any maternal organs. Examination of uteri showed that implantation had taken place, but that each conceptus was represented by a necrotic mass of undeveloped tissue. The myometrium showed no histologic change. However, occasional macrophages filled with hemosiderin were noted and probably indicated previous bleeding.

Saponin have been reported in other species of Momordica. Treated mice were therefore tested for evidence of in vivo hemolysis. None was found. (This work was supported in part by General Research Support Grant FR-5697-02 from the General Research Support Branch, Division of Research Facilities and Resources, National Institutes of Health.)

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STUDIES WITH LA CROSSE VIRUS, A CALIFORNIA GROUP ARBOVIRUS. A.J.Banes* and P.H.Coleman. Dept. of Microbiology, Health Sciences Div., Va. Commonwealth Univ., Richmond, Va. 23219

The antigenic relationships within the California arbovirus group have been extensively investigated however, few structural or biochemical studies have been reported. Preliminary studies in the characterization of the La Crosse subtype of California virus indicate that the virus produced plaques with Vero cells in the presence of the following drugs; amantidine HCl (5 ug/ml); guanidine HCl (100,50,5 ug/ml); 5-bromodeoxyuridine (5-BUDR) (100,50,5 ug/ml), but did not produce plaques in the presence of cycloheximide (50,25, 5 ug/ml). In addition, La Crosse virus titer did not change significantly compared to controls when the virus was titered in a plaque assay system with Vero cells that were preincubated 1 hr in 50 ug 5-BUDR/ml and received 50 ug 5-BUDR/ml in the overlay. In a similar system the titer of Vaccinia virus was reduced by at least three logs while the titers of Anopholes B and Bunyamwera control viruses were unchanged. Plaque formation by La Crosse, Anopholes B, and Bunyamwera viruses in the presence of 5-BUDR suggests that these are RNA viruses. Inhibition of La Crosse virus in the presence of cycloheximide indicates that protein systhesis is required for plaque formation, while plaque formation in the presence of amantidine HCl and guanidine HCl indicates that La Crosse virus is unlike the myxoviruses or enteroviruses respectively, in response to these drugs.

COMPARATIVE CARBOHYDRATE METABOLISM OF MEMBERS OF THE GENUS SPIRILLUM. Phillip B. Hylemon* and N.R. Krieg. Dept. of Microbiology, Health Sciences Div., Va. Commonwealth Univ., Richmond, Va. 23219 and Dept. of Biology, Va. Polytechnic Inst. and State Univ. Blacksburg. Va.

Inst. and State Univ., Blacksburg, Va.

Three species of the genus Spirillum which utilized carbohydrates as a sole source of carbon and energy have been studied for the presence of carbohydrate catabolizing enzymes. Spirillum lunatum, which catabolized several hexoses, possessed high specific activities of the Entner-Doudoroff (ED) pathway and related enzymes, 6-phosphogluconate dehydrase, 2-keto-3-deoxy-6-phosphogluconate aldolase, gluco-kinase, and glucose-6-phosphate dehydrogenase, but little, if any, enzymatic activity unique to the pentose phosphate (PP) and Embden-Meyerhof-Parnas (EMP) pathways. Although synthesis of the latter enzymes were largely unaffected by growth environments, that of the former was stimulated by carbohydrate. Growth of S. lunatum on mannitol/casamino acids resulted in induction of a soluble NAD mannitol dehydrogenase. Spirillum itersonii and Spirillum peregrirum possessed enzymes unique to the ED pathway and low or undetectable activities of enzymes unique to the EMP or PP pathways. The ED enzymes were induced by growth on fructose/casamino acids but not on succinate/casamino acids while the specific enzyme activities of enzymes unique to the PP or EMP pathways were largely unaffected by culturing conditions. S. peregrinum was the only species studied which possessed an inducible membrane associated glucose dehydrogenase.

BACTERIOPHAGES OF PSEUDOMONAS PSEUDOMALLEI. G.D. Jacobs*, H.P. Dalton, M.J. Allison*, and M.R. Escobar* Div. of Clinical Pathology, Health Science Div., Va. Commonwealth Univ.

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The lysogenicity of certain strains of P.pseudomallei, the etiologic agent of melioidosis, was reported on in 1957 by Smith and Cherry (J.Bact.,74:668,1957). The present study was undertaken to extend their work, which could ultimately lead to the establishment of a phage typing schema for the pseudomallei group (P.pseudomallei and P.mallei). A total of 48 strains, originally recovered from patients in Vietnam, were assayed for phage activity. Thirty-one bacteriophages were obtained from lysogenic strains of P.pseudomallei. Host range testing revealed specificity to the pseudomallei group. Eight other pseudomonas species tested were not susceptible. Propagation of phages to higher titers than those of the original isolates increased both the host range and the intensity of the individual reactions, Ninety-eight percent of the P. pseudomalle1 cultures were lysed by at least one of the isolated phages and 87% were lysed by at least two or more. Two phages were found to be active against 68% of the \underline{P} . pseudomallei cultures. These findings compared favorably with those of Smith and Cherry who found approximately 20% lysogenicity and 50% susceptibility for P.pseudomallei.

These results may be valuable for epidemiological studies as well as specific identification of the pseudomallei group and/or confirmation of the laboratory diagnosis obtained by

other means.

ENHANCED TOXICITY OF COMBINATIONS OF ANTITUMOR DRUGS AND DACTERIAL ENDOTOXIN. Nelda M. Marecki* and S. G. Bradley, Dept. of Microbiology, Med. Col. of Va., Richmond, Va. 23219

The administration of cytosine arabinoside (CA), mitomycin C (MC), 6-mercaptopurine (6-MP), 6-methyl mercaptopurine

riboside (6-MMP), or sparsomycin (S) with Salmonella typhosa endotoxin (E) resulted in increased lethality for BALB/c mice. The dose of E necessary to kill half of the mice (LD50) was 15.8 mg/kg in normal mice and 11.45 mg/kg in mice given 200 mg CA/kg. A dose of 200 mg CA/kg is not lethal. The LD50 of 6-MP was 271 mg/kg in normal mice and 67.9 mg/kg in mice given 1 mg E/kg. The LD50 of E was 0.61 mg/kg in mice given 100 mg 6-MP/kg. The LD50 of 6-MMP was 170 mg/kg in normal mice and 25 mg/kg in mice given 100 mg 6-MMP/kg. The 5-day LD50 of MC was 16 mg/kg. The 5-day LD50 of E was 3.9 mg/kg in mice given 8 mg MC/kg. The LD50 of S was 3.78 mg/kg in normal mice and 1.05 mg/kg in mice given 1 mg E/kg. The LD50 of E was 0.07 mg/kg in mice given 2 mg S/kg. Administration of E with either 5-fluorouracil (5-FU) or 5-fluorouracil deoxyriboside (5-FUdR) did not result in an increased lethality. The LD50 of 5-FU was 118 mg/kg, and that of 5-FUdR was 200 mg/kg in normal mice.

The effects of the above drugs on hexobarbital sleeping times were determined using doses less than the LD50 and administered either 24 hr prior to testing or simultaneously with 80 mg hexobarbital/kg. Pretreatment with all drugs consistently resulted in an increased sleeping time.

A CONTROLLING GENE FOR THE TRANSCRIPTION OF LATE GENES IN SALMONELLA PHAGE P22. Robert A. Kolstad, Dept. of Microbiology, Health Sciences Div., Va. Commonwealth Univ., Richmond, Va. 23219.

Gene 79 maps to the right of genes 18 and 12, required for DNA replication, and to the left of all the known late genes, which direct the synthesis of endolysin and structural proteins. Functions to the left of 79 - DNA synthesis and lysogeny - are independent of gene 79. In 79 infection structural proteins are not synthesized and lysis does not occur. The position of gene 79 on the viral genome as well as its pleiotrophic effect on late gene products suggests it to be analogous to gene Q of λ . Unlike Q, which is very leaky, the requirement for 79 is stringent. Q promotes lat gene transcription. Q infection is highly leaky, due to extension bypass of gene N. A comparison of gene N in λ with its closest counterpart in P22, gene 25, suggests that Q promotes late the latter is more limited. The stringent requirement for gene 79 may reflect a limited gene 25. Gene 79 may function as Q but my be controlled differently.

THE QUANTITATIVE AND QUALITATIVE NATURE OF ACTINOMYCINS PRODUCED IN THE PRESENCE OF THE D- AND L- ISOMERS OF PIPE-COLIC ACID. W Stratford May* and J.V. Formica, Dept. of Microbiology, Health Sciences Div., Va. Commonwealth Univ., Richmond, Va. 23219

New cogeners of actinomycin were synthesised by Strepto-myces antibioticus when growing cultures were supplemented with pipecolic acid (PA). It was determined that PA replaced L-proline at the "imino acid" site in one or both pentapep-tide chains of the antibiotic. The pattern of actinomycins produced, however, differed when D- or L- or a combination of D- and L- PA was added to the medium. Separation of the actinomycins by circular chromatography.indicated that actinomycins produced in the presence or absence of D-PA were the same, while those produced in the presence of L-PA enabled synthesis of pipecolic-actinomycins. Examination of acid hydrolysates of these actinomycins revealed that PA was incorporated into the antibiotic from cultures supplemented with L- or DL-PA. There was no evidence for incorporation of PA when cultures were supplemented with D-PA. In addition, exogenous L- or DL-PA inhibited total actinomycin production by as much as 50%, whereas the addition of D-PA enhanced actinomycin production. At the same time, these analogues of proline had no effect on growth. Furthermore, the isomer of PA incorporated into pipecolic-actinomycins was found to be I.-PA

REGULATION OF ALANINE DEHYDROGENASE IN BACILLUS LICHENIFORMIS. S. M. McCowen* and Paul V. Phibbs, Jr* Dept. of Microbiology, Health Sciences Division, Virginia Commonwealth University, Richmond, Virginia 23219

Cell-free extracts of Bacillus licheniformis were found to contain high specific activities of nicotinamide adenine dinucleotide (NAD)-dependent L-alanine dehydrogenase (ADH) [L-alanine: NAD oxidoreductase (deaminating) EC 1.4.1.1.]. High specific activities (3.5-5.5 I.U. per mg protein) were found in extracts of cells throughout growth cycles when Lalanine served as carbon and nitrogen source. Specific activities were minimal (0.02-0.04) during growth on glucose but increased significantly within 5 hours following logarithmic growth. Addition of 10 mM glucose to logarithmic phase cells growing on L-alanine resulted in apparent repression of enzyme synthesis. Approximately 50% of the original specific activity remained after one generation. Derepression of enzyme synthesis during growth on glucose, upon the addition of 20 mM L-alanine, was demonstrated by a 41-fold increase in ADH specific activity after two cell generations. The enzyme was partially purified from crude extracts of B. The Kind entryme was partially purified rine trude extracts of $\underline{\mathbf{B}}$. Licheniformis and apparent kinetic constants were determined. The Km values for each substrate were: NH_{4}^{4} , 1.2×10^{-2} M; Pyruvate, 4.0×10^{-4} M; NADH, 2.5×10^{-5} M; L-alanine, 5×10^{-3} M; NAD, 4.5×10^{-5} M. A catabolic role for ADH during vegetative growth on L-alanine and during sporulation of cells cultured on glucose is proposed on the basis of these experimental results.

INTERACTION OF CYCLOPHOSPHAMIDE WITH BARBITURATES. W.C.Rose* and S.G.Bradley. Dept. of Microbiology, Commonwealth Univ., Richmond, Va. 23219

BALB/c mice simultaneously given cyclophosphamide (C) and pentobarbital (P) experienced an acute death commencing within 15 min after challenge. The dose-lethal response curve of P was potentiated 2.6 fold in a parallel manner by 375 mg C/kg (LD50 reduced from 131 to 51 mg P/kg). Nonsimultaneous injection of C and P did not enhance lethality. NYLAR mice responded in a manner similar to BALB mice when challenged with C and P. Hexobarbital and phenobarbital substituted successfully for P in causing acute death when injected with C. Administration of C with each barbiturate resulted in a more rapid onset of sedation and marked increases in sedation when compared to mice treated with barbiturate alone. BALB mice pretreated with phenobarbital (65 mg/kg- once daily for 4 days) were protected (p < 0.025) against a lethal challenge of 500 mg C/kg + 45 mg P/kg, despite an increased (p<0.05) reactivity to 500 mg C/kg only. Metabolism of aminopyrine in liver homogenates derived from C-treated mice were not substantially different from control levels. Preliminary investigations indicated that P levels in brain tissue, derived from C+P and P-only treated mice 15 min after injection, were not substantially different.

CHARACTERIZATION OF THE SPORULATION PIGMENT OF Streptomyces venezuelae. T. Tang* and S.G. Bradley. Dept. of Microbiology, Health Science Div., Va. Commonwealth Univ., Richmond, Va. 23219

Streptomyces venexuelae S13 produces a pH indicator pigment on glucose minimal agar (GM) consisting of 2% glucose, and 0.2% each of MgS04·7H20, KN03, and Na2HP04. Pigmentation of S13 on GM agar appears to be closely associated with sporulation which normally requires 7-10 days at 30 C. The present study was directed toward an evaluation of medium composition with respect to growth and pigmentation by S13 both on solid and in liquid media. Glucose could be replaced by other sugars, amino acids, and intermediary metabolites in supporting growth and pigmentation. However, succinate, aspartate, glutamate and asparagine were found to be superior to glucose for pigmentation. Ca(II) could replace Mg(II) in GM agar; other tested divalent cations were inhibitory to growth. With respect to nitrogen source, KNO3 proved to be the best. Pigmentation of S13 in liquid media was first noted in asparagine minimal broth (AMB). Additional experiments showed that S13 also produces comparable amount of pigment with the following carbon sources in minimal broths: glucose, proline, serine and threonine (TMB). Glucose added to AMB and TMB promoted growth, but delayed pigment production.

Section of Psychology

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

THE PERSONALITY CHARACTERISTICS OF FEMALE COLOR DREAMERS. Ira B. Albert, and Bruce McGregor*. Dept. of Psychology, Old Dominion University, Norfolk, Va. 23508

A modified form of the Adjective Check List was administered to 63 female undergraduates. The adjectives checked by female color dreamers were compared to those checked by female non-color dreamers, and several interesting trends emerged. Non-color dreamers scored significantly higher on two scales: "abasement" and "deference". The adjective most characteristic of non-color dreamers was "despondent", while the adjective most characteristic of color dreamers was "determined".

AN EVALUATION OF THE ARCHIMEDES SPIRAL AFTEREFFECT UTILIZING OPERANT PROCEDURES. John Ballurio* (Sponsored by George Kent), Uepartment of Psychology, Bridgewater College, Bridgewater, Va. 22312

The purpose of this research was to develop methods and

The purpose of this research was to develop methods and instrumentation for studying the spiral aftereffect in animal subjects. Humerous studies have been reported using children and adults, brain damaged and normal, with conflicting findings. It was assumed that one possible reason for such conflicting findings might be the methods employed in studying this illusion. A cinnamon Ringtail monkey, Cebus Albifrons, served as subject. Lever pressing behavior was maintained under water deprivation and water reinforcement. The stimulus consisted of a 12-inch Archimedes Spiral located a meter in front of the living cage. Two levers were mounted on the cage. Discrimination training was given to develop differential responding in the presence of clockwise and counterclockwise rotation of the spiral. Operating under a Chain VR-VR reinforcement schedule, the animal was given training until criterion performance was reached. Threshold determinations of the spiral illusion were made by stooping the rotation and examining the levernessing which followed. This permitted determination if the subject perceived the spiral aftereffect.

THE REDUCTION OF SMOKING THROUGH COVERT SENSITIZATION.
R. A. Belvea* (Sponsored by Donald Witters), Department of Psychology, Bridgewater College, Bridgewater, Va., 22812
The purpose of this study was to determine the effect-

The purpose of this study was to determine the effectiveness of Covert Sensitization in reducing cigarette smoking. Covert Sensitization, a treatment program developed by Cautela, is a variant of Wolpe's systematic desensitization. Four volunteer college students served as subjects for a period of ten weeks. The initial five weeks were used to gather baseline data on the situations and daily number of cigarettes smoked. The remainder of the investigative period employed the Covert Sensitization procedure. Through the use of stories the S visualized the pleasurable behavior, smoking, and paired it with an imagined aversive stimulus, vomiting. Smoking became a conditioned aversive stimulus and reinforced avoidance behavior. The frequency of smoking data indicate that Covert Sensitization is an effective method of reducing smoking behavior.

A SURVEY OF RECIPIENTS OF FAMILY PLANNING SERVICES- BIO. DATA AND ATTITUDES, <u>Mandi H. Brown</u>* and Frederick B. Rowe Dept. of Psychology, <u>Handolph-Macon Woman</u>'s Col., Lynchburg, Va. 24504.

This survey was conducted at the Neighborhood Free Clinic for Family Planning (NFC/FP) and the Family Planning Clinic at the Public Health Dept. (FPC/PHD), both located in Lynchburg, Va. A questionnaire was employed in the survey, developed by the authors in response to the request of the administrative personnel of both clinics, to determine the attitudes and opinions of the recipients regarding family planning services at each clinic. The questionnaire was administered to the recipients on their first visit during the period over which the survey was conducted, Oct. 18 to Dec.10,1971. The FPC/PHD was located within the health Dept. complex of services and offered its services one morning per week from 8:30 am to 12 noon. The NFC/FP was separately located and had been organized solely to provide family planning services. It was open for a doctor's appointment 10.25 hours on three days per week in the evening, morning, and afternoon, respectively, and open every day from 8:30 am to 5:00 pm with a nurse in attendance for assistance and counseling. From the basic biographical data, it was observed that the backgrounds of the recipients at the respective clinics did differ, but there was overlapping in several of the characteristics. On items designed to educe opinion or preference, there was relative agreement among the recipients at both clinics.

A SURVEY OF MNEMONIC TECHNIQUES USED BY COLLEGE STUDENTS IN SERIAL LEARNING. J. V. Buonassissi*and K. A. Blick. Dept. of Psychology, Univ. of Richmond, Va. 23173

College students reported eight categories of memory aids

College students reported eight categories of memory aids that they would employ in learning a serial task. Although no significant differences were found between men and women by category of memory aids reported, there was a significant difference among the eight categories. First letter and simple repetition accounted for 49% of all memory aids, while the remaining 52% were divided almost evenly among imagery, phonetic clustering, descriptive story, mediation, other, and semantic clustering. Clearly, the first-letter technique was the most popular mnemonic associated with the serial task.

A TEST OF INDIVIDUAL RECOGNITION IN BLUEGILL SUNFISH USING OPERANT PROCEDURES. Margaret Butler* and David A. Johnson, Dept. of Psychology, Sweet Briar College, Sweet Briar, Va. 24595.

In a study designed to substantiate the assumption of individual recognition frequently occuring in theories of animal social behavior, three bluegill sunfish, Lepomis macrochirus, were operantly trained to strike a submerged manipulandum to obtain food reinforcement. The same animals were then introduced to a discrimination learning task intended to appraise the ability of this species to discriminate among its conspecifics on an individual basis. The two-choice, successive, discrimination task employed back projected color slides of conspecific fish as the discriminanda.

The results were not conclusive in that none of the three subjects had yet attained a typical discrimination learning criterion. However, the data reveal significant trends in the predicted direction. In view of similar studies which often report that very large numbers of trials are required for lower vertebrates to reach standard learning criteria, it seems entirely possible that these subjects have attained some intermediate point on a learning curve which would eventually reach criterion levels.

THE EFFECTS OF RESPONSE INVOLVEMENT AND COMPETENCE ON OPINION CHANGE. P. Campsen* and V.J. Derlega*. Dept. of Psychology, Old Dominion Univ., Norfolk, Va. 23508

(Sponsored by I.B. Albert).

Cognitive dissonance theory's predictions about the relationship between response involvement and opinion change were tested. Opinion change increased significantly as a function of response involvement under low competence, whereas opinion change did not change as a function of response involvement under high competence. The results were interpreted in terms of the notion of evaluation apprehension.

THE CONSEQUENCES OF SENSORY BOMBARDMENT. D.M.DAVENFORT* and C.L.WINSTEAD, Jr.* Dept. of Philosophy and Psychology, Va. Mil. Inst., Lexington, Va. 24450

The experiments were performed to draw correlations between sensory bombardment and fatigue, learning, creativity, blocking, time lapse, and the state of mind produced therein. Subjects were placed inside a highly controlled environment under the effects of diverse stimuli, including a taste pill containing the four basic tastes, strobe light, tetralight, trilight, color wheel, tape recordings, frequency generators, air conditioning, heat gun, electric shocks, vibrating pillows, ice pack, mixed odors, heating pillows, and a Niagra cyclorama chair. Subjects were tested before and after bombardment as the baseline reference for performance as tested during bombardment. Tests included short term memory, psychomotor coordination, and creativity. Experimenters conclude among other results, that there is a positive correlation between bombardment and fatigue, bambardment and increased, learning, and bombardment and blocking. Some complementary results include both tactile and visual hallucinations.

REHEARSAL AND ENCODING AS FACTORS IN MASSED AND DIS-TRIBUTED PRACTICE. John C. Dovel*. Dept. of Psychology, Washington and Lee Univ. (sponsored by David G. Elmes), Lexington, Va. 24450

To investigate possible differences in the subjective processing of massed practice (MP) items as opposed to distributed practice (DP) items, recall of words which immediately followed MP and DP items was noted in a free recall (FR) task that involved either an additional rehearsal equating task or presentation rates of 2, 3, and 4 sec. per item. In lists of 88 presentations which included MP items and DP items of lags 3 and 10, rehearsal of a given word was assumed to lower the probability of recalling the immediate after item.

The rehearsal equating task attenuated after item differences; however, increased recall with increased lag was still observed, suggesting other contributing factors such as differential encoding. For the FR task under different presentation rates, a significant reduction in recall of after items was found between lags 0 and 3 while recall appeared to increase from lags 3 to 10. A possible non-monotonic relationship between differential rehearsal and encoding was supported. Effects of presentation rate on differential processing was observed though not significant. SUBJECT VARIABLES AS PREDICTORS OF PAIRED ASSOCIATE

LEARNING. <u>Laurel Faile*</u> (sponsored by L. J. Tromater), University of Richmond, Richmond, Va. Three tests from the "Kit of Refrence Tests for Cognitive Factors" were used to predict scores on Cognitive Factors" were used to predict scores on a paired - associate learning task. These tests were administered to 64 male and female introductory psychology students at the Univ. of Richmond. CVC nonsense syllables with a mean meaningfullness value of 2.32 were used as items on the paired associate learning task. A significant multiple convolution was obtained at the Of level. correlation was obtained at the .05 level.

SPEED OF CONFLICT RESOLUTION AS RELATED TO THE TAYLOR MANIFEST ANXIETY SCALE. Jeffrey C. Fracher* and Kenneth A. Blick. Dept. of Psychology, University of Richmond, Va. 23173

Verbal and motor conflict behavior as a function generalized drive level was examined. Twenty Verbal and motor conflict behavior as a function of generalized drive level was examined. Twenty Ss in each of two groups, designated as high drive (HD) and low drive (LD) according to extreme scores on the Taylor MAS, had to resolve AP-AP, AV-AV, and DAP-AV conflicts of both a motor and a verbal form. Speed of conflict resolution was the dependent variable and a 2x3 factorial design for repeated measures on the second, or Conflict, factor was used. or was used.

Regarding the two drive groups in the motor phase of study, results agreed with past findings in that the HD group, as predicted, took significantly longer (p<.05) to resolve all three types of motor conflicts than the LD group. Only AP-AP was found to differ significantly from both other

types.

In the verbal phase of the study the HD group, also as predicted, took significantly longer to resolve all types of conflicts than the LD group. Also, the three conflict types were found to differ significantly (p<.05). The possible effects of a confounding variable on the verbal phase were discussed.

LANGUAGE COMPLEXITY AND CONCEPT FORMATION DIFFERENCES IN MIDDLE CLASS AND DISADVANTAGES PRESCHOOLERS. B. Francke*, and K. Riccardi*, Dept. of Psychology, Sweet Briar College, Sweet Briar, Va. 24595

Twenty middle class and 20 environmentally deprived preschool children were compared on three cognitive ability dimensions, 1) complexity of verbal productions, 2) attainment of the oddity concept, 3) attainment of verbal concepts varying in degree of abstraction. Middle class children produced significantly more and more complex verbalizations than did the disadvantaged children. The oddity concept was attained in significantly fewer trials by the middle class children than by the disadvantaged group. A concept attainment task which involved the labeling of abstract concepts with nonsense words proved too difficult for either group and was discontinued. The observed differences between the two groups of subjects were interpreted as being due primarily to differences in environmental stimulation, with a major factor assumed to be the mother's "level of control" of the child. In addition there is some indirect evidence that in the case of the disadvantaged subjects a long history of intermarriage in their locality may have produced a limited gene pool which could account for some of the observed variance.

ACCURACY OF "FEELINGS OF KNOWING"IN VERBAL LEARNING: Susan J. Good." Dept. of Psychology, Univ. of Va., Charlottesville, Va. 22903
"Feeling of knowing" may be described as the feeling that one could recognize a correct response when he cannot recall it. After viewing 48 word triads, Ss were tested on their ability to recall the third word in each triad, given one or both of the preceding words as a cue. At the same time, Ss indicated their confidence that they could later recognize the third word in the triad. Such feelings of knowing were highly correlated with performance on a cued-recognition test that followed. Two-word cues led to better test that followed. Two-word cues led to better recall than one-word cues, whereas the number of cues available on the recognition test did not affect the recognizability of words not recalled. (aided in part by NSF grant GY 7414)

POST REINFORCEMENT PAUSE IN PIGEONS UNDER SOCIAL AND NON-SOCIAL CONDITIONS, Sally Henry*, B. D. MacEwen,* Department of Psychology, Mary Washington College, Fredericksburg, Virginia 22401.

Changes in post-reinforcement pause were observed for pairs of pigeons under fixed-ratio schedules, utilizing two social situations characterized as cooperation or competition and one non-social, when one bird under a fixed-ratio schedule responded alone. Post-reinforcement pause is the elapsed time between termination of a period of access to food until the initiation of the next response. In competition, when the key light comes on in their separate, but identical chambers, only the first bird to peck his key is reinforced. In cooperation, for both birds to be reinforced, they must peck their respective keys simultaneously, or the response of one must follow the response of the other within a specified time interval. In comparison to the non-social condition, post-reinforcement pause generally decreased in competition and increased in cooperation. In competition, a low proportion of reinforcement meant that a bird repeatedly resulting in longer post-reinforcement pause, which then resulted in even lower proportions of obtained reinforcements. If the proportion became too low, the birdsstopped responding. A high proportion indicated a bird repeatedly "won" and pauses would decrease even more. In cooperation, a short post-reinforcement by one bird resulted in the pairs not meeting the criterion for cooperative responding, thereby decreasing both bird's proportion of obtained reinforcers. ONE-TRIAL VS. INCREMENTAL LEARNING: A RE-EVALUATION USING SIGNAL DETECTION THEORY. J. W. Hysms* and W. H. Leftwich. Dept. of Psychology, Univ. of Richmond, Va. 23173

Ss were presented with a list of six A-B pairs followed

Ss were presented with a list of six A-B pairs followed by a recognition task which consisted of either an A-B (original member) or an A-X(new) psir on each of three identical trials. Ss were required to indicate a binary decision as well as a confidence rating. Ss making correct responses on trial 1 were not exposed to trial 2; those correct on trial 2 were not exposed to trial 3. From these data receiver operator curves for all three trials were plotted and d' values computed. The curves were virtually overlapping and the d' values were not significantly different at the .05 level. Because the results do not indicate an increment in learning as a result of practice, support was lent to the one-trial position.

THE EFFECT OF FEMININE ROLE ORIENTATION ON PERCEPTION.

S. H. Klemmack* ond E. E. Kemp*. Department of Psychology,
Rodford College, Rodford, Virginia 24141.

Women's attitudes toward their societal roles should influence their perception of words that are connotatively related to these roles. Twelve words, ruled by judges as descriptive of career women or the housewife, were presented to undergraduate females. Subjects were previously classified by a questionnaire as either accepting or rejecting the traditional women's role.

Recognition scores for subjects who most accepted or rejected the traditional role were compared. No significant differences were found in the trials required for women of different role orientations to recognize words representing either orientation.

These results, plus those from an earlier study, suggest that women's attitudes toward their own roles have not yet differentiated sufficiently to affect perception of value-làden words.

A COMPARISON OF GROUP AND INDIVIDUAL RATINGS OF PROFESSORS. Gary F. Krapf* and Daniel L. Johnson. Dept. of Psychology, Radford Col., Radford, Va., 24141.

To test the polarization effect of group

To test the polarization effect of group decision making, students were asked to rate their professor on a standard faculty rating form. These same students were then randomly assigned to groups of size four, five, or six and asked to come to consensus decisions on the same items they had previously rated individually

items they had previously rated individually.

Analysis of the individual and group ratings supported the hypothesis that group decisions would be more extreme than the average decisions made by individuals. Results supported previous findings and confirmed the supposition that laboratory findings in small group decision making could be extended to group evaluation of teachers in real world situations.

DO FEMALES PERCEIVE FEMALE INSTRUCTORS TO BE INFERIOR? Patrice A. McMonigle* and Daniel L. Johnson. Dept. of Psychology, Radford Col., Radford, Va. 24141

Previous research has shown that in certain

Previous research has shown that in certain conditions females are prejudiced against females. The present studies attempted to show that females who had achieved in a field would be rated equal to their male counterparts and females who had not yet succeeded in a field would be rated lower than their male counterparts.

lower than their maie counterparts.

Two experiments manipulated the post-graduate degree and sex of college instructors in a 2 X 2 factorial design. In Experiment 1 non-Ph.D's received significantly higher ratings than did Ph.D's. There was no sex difference or interaction effect. Experiment 2 showed no significant differences among degrees, sex, or sex/degree interaction.

CONTOURS OF PERSONAL SPACE AS INFLUENCED BY SEX OF SUBJECT AND SEX OF ASSISTANT. D. S. Nice.* Dept. of Psychology, Col. of William and Mary, Williamsburg, Va. 23185
In order to investigate the influence of sex variables on

In order to investigate the influence of sex variables on the boundries of personal space, 20 male and 20 female subjects (§s) were approached by a male and female assistant (Am and Af) from each of four directions; the front, right, left, and rear. On each trial, § 'clicked' a clicker to indicate that Am or Af had approached to a normal interaction distance and should stop. Distances were recorded by a male experimenter who also recorded extremity measurements for each § and subtracted them from distances to correct for body size. §s then completed a postexperimental questionaire which rated Am and Af on absolute, and relative attractiveness, and relative status. It was hypothesized that (a) distances would differ as a function of direction of approach, (b) the female assistant would be permitted closer approach than the male, regardless of subject sex, and (c) total area of personal space would be smaller for female than for male §s. Hypotheses (a), and (b) were confirmed (p < .01, and p < .025 respectively). Hypothesis (c) was not confirmed. The relative attractiveness ratings reached significance, and the implications of those ratings were discussed.

THE EFFECT OF NARRATIVE STORIES ON RECALL. Dale Parks*.
Dept. of Psychology, Randolph-Macon Woman's Col., Lynchburg,
Va. 24504

Two study techniques were investigated: a control method of normal study or a narrative method by constructing a story around the words. Twelve serial lists of 10 nouns were presented. Each \underline{S} learned four lists of high-, four of low-, and four of zero-inter-item associative strength. Control \underline{S} s received a study time equal to that of their yoked narrative \underline{S} s. Two experiments were done. Probe lists were used in Experiment II to control for Narrative \underline{S} following instructions. In Experiment I, the only significant difference obtained was between associative strength for the session delay and delay interval recall, at 7, 14, and 30 days. With the probe technique, significant differences were obtained between study techniques and associative strength in the session delay recall. These results support other studies in this area.

AN ANALYSIS OF RATIO AND INTERVAL RESPONSES TO MULTIDIMENSIONAL STIMULI. Elizabeth Pigg* and Ricardo

MULTIDIMENSIONAL STIMULI. <u>Elizabeth Figg</u> and Ricardo Dobson. Dept. of Psychology, Mary Washington College, Fredericksburg, Virginia 22401

Forty observers (Os) judged the similarity of pairs of symmetrical patterns. The patterns, generated by the Minkowski unit distance equation, define a shape continuum which includes a cross, diamond, circle, square, and intermediate forms. Three subsets of fifteen patterns, composed of concave, convex, or both types of patterns, were paired in all possible combinations within a subset. Half the Os made interval scale judgments, but the other half made ratio scale judgments of the similarity of pairs of patterns. Each of these halves were further subdivided so that Os saw either the convex or concave subsets of patterns and the combined subset in a counterbalanced order.

The impact of the stimulus subset manipulation was assessed on multiple levels of analysis. When the combined stimulus subset was presented prior to either the concave or convex subsets, the latter subsets were generally reported to be more similar than when they were not preceded by the combined subset. Content and distance multidimensional scaling analyses revealed that both the number and type of important perceptual attributes of the Minkowski patterns depended on which stimulus subset was presented. The psychophysical significance of the attributes was further verified by regression of the dimensional coordinates against objective indices of these attributes.

ELECTRO CONVULSIVE SHOCK: ITS RELATIONSHIP TO STATE-DEPENDENT LEARNING. P. J. Ray*, S. D. Johnston*, S. O'Toole*, C. A. Willits*, D. L. Wood*, G. C. VanDyne*, Dept. of Psychology, Sweet Briar Col., Sweet Briar, Va. 24595

Twenty albino rats were given extensive preliminary training in pressing the left bar in a 2-bar Skinner box for food reinforcement. On Day 1 the habit was reversed by selectively reinforcing responses on the right bar. The Immediate ECS Group was given ECS within 10 seconds following criterion performance. On Day 2 all S's were allowed free access to food pellets for 2 min. and the 24 hr. Hungry Group and the 24 hr. Satiated Group were given ECS at this time. A non-ECS Control Group did not receive ECS on either Day 1 or Day 2. Retention of reversal training was tested on Day 3, 48 hours following training, by recording the number of R's on each bar during extinction. As hypothesized, the disruptive effects of ECS upon retention of a new habit were a function of both its immediacy and the similarity between the conditions present during ECS and recent learning.

"SHEEP" AND "COATS" AS JUDGES OF EXTRA-SENSORY PERCEPTION. Jane Reeb* and Mary Witt*, Dept. of Psychology, Sweet Briar Col., Sweet Briar, Va. 24595

A study in General ExtraSensory Perception was conducted

to test Certrude Schmeidler's findings that believers ("Sheep"), score higher on ESP tests than non-believers ("Coats"), (Schmeidler, 1969). The experiment was two-fold. In the first part, 25 subjects were asked to respond to five target pictures presented individually in such a way that any information about them was received by other than known sensory channels. In the second part, 10 believers and 10 non-believers in ESP were asked to match responses of subjects in the first part to the correct target pictures.

Neither the mean of believers' successful matches, nor the mean of non-believers' successful matches deviated significantly from chance expectation. Therefore, the results of the experiment were non-significant and did not support Schmeidler's findings.

A COMPARISON OF COVERT SENSITIZATION AND IN-VIVO TECHNIQUE IN THE EXTINCTION OF SMOKINC BEHAVIOR. Joseph E. Reish*, Marie Waters, and Daniel Johnson, Psychology Dept., Radford Col., Radford, Va. 24141

A Covert Sensitization (CS) group, which consisted of subjects (Ss) who listened to tape-recorded descriptions of aversive scenes, and an In-Vivo (IV) group, which were presented aversive stimuli in the form of hot air mixed with cigarette smoke, were compared with two control groups as to the effectiveness in the extinction of smoking behavior. The results indicated that there was no significant difference between the two treatment procedures, although both were significantly more effective in the reduction of smoking behavior than the two control groups. The control groups consisted of a Contact Control (CC) group, in which the Ss were informed that they were part of the experiment, and a No-Contact Control (NC) group, which were experimentally naive. No significant difference between the control procedures was demonstrated.

Also, a validity check on the verbal reports of the Ss' cigarette consumption was made via telephone contact with the experimental Ss' friends (confederate Ss). Significant agreement was found between the experimental Ss and the confederate Ss in only the CC and NC groups, indicating a possible lack of validity in the reports of cigarette consumption of the Cs and IV groups.

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ISCLATION OF ITEMS IN FREE RECALL. Lester W. Sanders, III*, (sponsored by David G. Elmes). Washington and Lee Univ., Lexington, Va. 24450

The effect of combining the Von Restorff phenomenon with the massed and distributed presentation of items was studied. The list consisted of two presentations each of 35 common English words with a lag of six items between distributed presentations. The words were printed in block letters on index cards, non-isolated items in black ink and isolated items in red, presented at a three second rate. There were three conditions of isolation in both the massed and distributed conditions. Either the first, second, or both presentations of three critical items in each list (massed or distributed) were isolated. It was found that isolation of massed items resulted in better recall of the massed than distributed items. Furthermore, although results showed superior recall in the "double isolated" condition, it was found that the isolation of the initial presentation only of the critical items produced recall markedly superior to that with isolation of the second presentation only and approaching the recall level of the "double isolated" condition in both the massed and distributed conditions. These results seem to indicate that attentional processes play a major role in producing the observed differences in recall between items presented with massed and distributed practice and between isolated and non-isolated items.

THE MODIFICATION OF SPEECH PATTERNS IN AN INSTITUTIONALIZED MENTALLY RETARDED CHILD. Marilyn Shrum* (Sponsored by

Donald Witters), Bridgewater College, Bridgewater, Va. 2 A thirteen year-old institutionalized male mongoloid whose pronunciation was unclear served as the subject. Two groups of stimulus cards consisting of sixteen pictures each were presented to the subject. In the first group of cards he was required to name the pictured object. In the second group of cards the requirement was to name the color of the object as well as the object. Tokens served as reinforcers and were delivered on a CRF schedule, being backed up with candy for every fifth token. An incorrect response resulted in a five second time-out. In the second phase of the experiment, ten four-word sentences were used as the stimulus material. Under the reinforcement procedure the number of words said clearly increased fifty per cent in the object group, fifty per cent in the color group, and forty-seven per cent in the sentence group. A reversal procedure was carried out, resulting in decreased clarity in all experimental phases. A reinstatement of reinforcement procedures increased the number of words said clearly to the previous level.

TRANSFER OF LEARNED HELPLESSNESS. P. D. Swart* (Sponsored by David G. Elmes). Dept. of Psychology, Washington & Lee Univ., Lexington, Va. 24450 The first study attempted to determine whether the ef-

fects of inescapable preshock on escape behavior would transfer to test situations employing a different aversive stimulus than that used in the pretreatment. Four groups of rats were used. Two groups were treated with inescapable preshock, one of which was then tested with shock as the aversive stimulus while the other was tested with aversive noise. Two groups did not receive preshock, one of which was tested with aversive shock, the other with aversive noise. It was found that both preshocked groups exhibited significant escape decrements compared to the nonpreshocked groups. It was concluded that the effects of inescapable preshock did transfer to test situations employing different aversive stimuli, and that this finding supported the learned helplessness theory.

The second study employed two more groups of rats, both of which were treated with inescapable aversive noise. and one of which was then tested with aversive shock, the other with aversive noise; thus attempting to show that the transfer of learned helplessness occurs with inescapable pretreatments of aversive stimuli other than shock.

A THREE MONTH ANALYSIS OF DRUG CALLS FOR RICHMOND HOTLINE. S. Wagener* and E. H. Tiller*. Dept. of Psychology, Univ. of Richmond, Va. 23173

Two hundred and thirty-four drug related calls were isolated from all calls to Richmond Hotline, a crises intervention service, received over a three month period. The drug calls were categorized and described according to type of drugs discussed, specific drug related problems including addiction and "tripping", the telephone manner of the caller, his age and sex, the time and length of call. The behavior of the Hotline listener was analyzed according to telephone techniques used to help the caller and the kind of referrals made to community agencies. The development and structure of Hotline, including the role and training of the listeners was briefly discussed.

THE EFFECTS OF INTIMACY AND DRESS ON DISCLOSURE IN SOCIAL SITUATIONS. J. Walmer*, V.J. Derlega*, and G. Furman*.

Dept. of Psychology, Old Dominion Univ., Norfolk, Va.

23508 (Sponsored by I.B. Albert).

Based on predictions derived from attribution theory, recipients of intimate information were expected to be more

attracted and disclose more to a conventionally dressed than to a deviantly dressed individual. Though these predictions were not confirmed, the results supported Jourard's notion of the "dyadic effect." Self-disclosure by female Ss was a positive function of the amount of disclosure input from another girl. THE EVALUATION OF TWO TECHNIQUES OF WEIGHT CONTROL: PERSUASION AND COVERT SENSITIZATION. Wayne Wampler* (Soonsored by Donald Witters), Department of Psychology,

The effects of two techniques of behavior change, Covert Sensitization and Persuasion, were investigated in regard to weight control. Thirteen volunteer subjects were divided into three groups, one control and two experimental. The subjects were assigned by a randomized block design created on weight to one of the three groups. The initial ohase of the study investigated two types of charting and data gathering. The subjects reported daily weights and amount of intake for various food types. Neither weighing nor intake charting were observed to be a significant factor in long term weight control. In the second ohase of the study all groups met an equal number of times and on the same days to receive one of the three treatments.

Experimental group procedures ran for thirty-five days with a total number of ten sessions. It was observed that only the weight of the Covert Sensitization group was affected by the treatment conditions.

SENSITIVITY TO VISUAL GAUSSIAN NCISE PATTERNS AS DETERMINED BY BINARY AND RATINGS. Charlotte Weitzel* and Ricardo Dobson, Department of Psychology, Mary Washington College, Fredericksburg, Va. 22401

Three trained observers $(\underline{0}s)$ made judgments as to the presence of a signal plus noise (SN) pattern adjacent to a noise (N) pattern with binary and 4-category rating response procedures. The computer-generated patterns consisted of Xs and blanks with SN patterns containing a greater mean number of Xs than N patterns. Two mean differences, 2 criterion levels, and 2 response procedures were factorially combined to produce 8 experimental conditions. Pay-off contingencies were varied in binary sessions to establish overall high and low criterion levels and to induce Os to adopt 3 cut-off points. For the rating procedure, high and low criterion manipulations were made by changing the a priori probability of SN trials. Each $\underline{0}$ was tested twice under each condition and a different condition was investigated in each

Individual protocols of all $\underline{0}s$ in rating sessions and of 2 Os in most binary sessions resulted in straight line z-coordinate ROC functions. Although criterion shifts were produced in rating sessions, Os were not influenced by pay-off condi-tions to adopt low criteria in binary sessions. Neither response procedures nor criterion manipulations affected de, but, as predicted by the TSD model, the effect of the mean difference manipulation on $d_{\mathbf{e}}$ was statistically significant.

DEVELOPMENT OF A LANGUAGE/PRE-LANGUAGE SCREENING INSTRUMENT. S. J. Zolczynski*, Rt. 1, Concord, Va. 24538, Elizabeth Stewart*, Div. of Speech & Hearing Services, Dept. of Pediatrics, Univ. of Virginia School of Med., Charlottesville, Va. 22901, and <u>Frederick B. Rowe</u>, Dept. of Psychology, Randolph-Macon Woman's Col., Lynchburg, Va. 24504.

An interview type instrument has been developed to yield

both an expressive and a receptive language age from infancy to five years. Items were drawn from the developmental literature and preliminary standardization procedures with institutional retarded (n=200), and Head Start children (n=49) are encouraging. Administration by paraprofessionals seems feasible in that their results compare favorably with evaluations done by certified speech pathologists.

A larger more representative sample is indicated as a next step in development of the instrument.

Section of Science Teachers

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

A SIMPLE NUTRITION EXPERIMENT FOR SECONDARY GRADES. J. E. Hardcastle. Chemistry Dept. Texas woman's University, Denton, Texas 76204 A simple nutrition experiment to demonstrate to children in the secondary grades the nutritive value of various foodstuffs is described. Briefly, the experiment is to maintain hamsters on specified diets, and weigh the animals periodically. The weight change is related to the nutrient content of the foodstuff as it is described on the package. The experiment can be performed with a minimum of equipment and materials, can be maintained in school rooms, and can yield good results in 2-3 weeks. After this experience the children want to and are able to help plan better family menus.

Section of Space Science and Technology

Fiftieth Annual Meeting of The Virginia Academy of Science May 3–5, 1972, Lexington, Virginia

ERROR ANALYSIS AND CONVERGENCE OF FINITE ELEMENT MODELS. \underline{F} . W. Barton, and R. T. Eppink*. Dept. of Civil Engineering, Univ. of Va., Charlottesville, Va. 22901

Although finite element methods have been utilized extensively for the analysis of complex structures, relatively little is known regarding the theoretical accuracy and convergence properties of the finite element models. The purpose of the present paper is to present the results of a study of the accuracy and convergence of standard beam elements in buckling problems. Specifically, the errors associated with buckling loads for classical beam problems will be considered.

A number of methods may be used to study accuracy and convergence in finite-element problems. One method used herein has been successfully applied to linear problems and is based on classical order of error analyses commonly used with finite difference approximations. Through the use of Taylor series expansions, differential equations are found from which convergence and principal error characteristics of the finite element equations may be determined. These resulting equations are then compared with known equations governing the continuum and the error terms are evaluated for selected problems.

Primary emphasis in this study is on the stability analysis of bar and beam structures. Discretization errors are determined for a wide range of problems and the sensitivity of the buckling load to these errors is studied.

EARTH SATELLITE ORBIT ANALYSIS. <u>J. J. Bosken*</u> and V. V. Gogolak*. Analytic Services Inc., Falls Church, Va. 22041

The use of artificial satellites to support earth programs (earth resources and communication satellites) is dependent upon satellite position as a function of time over the earth's surface. The problem analyzed is to determine the ground tracks of satellites deployed in 6 to 24 hour periods with emphasis on eccentric orbits. The study avoids sophisticated mathematical models and concentrates instead on the desirable properties of the physical parameters, exploiting the capabilities of commercial time sharing computer facilities. The analytic tools used are briefly discussed. Detailed diagrams showing the ground tracks of various satellite orbits are given.

LONG PERIOD MOTION OF A VIKING ORBITER. William J.
Breedlove, Jr., Engineering Mechanics Dept., Old
Dominion University, Norfolk, Virginia 23508
The Project Viking-Type Martian Orbiter provides

The Project Viking-Type Martian Orbiter provides a unique opportunity to estimate Mars' gravitational and atmospheric parameters from Celestial Mechanics experiments.

The parameter estimation schemes to be used at Langley Research Center for determining the desired properties of Mars involve a trajectory integration routine. A considerable savings in computer time will result if the "long period" trajectory equations are integrated rather than the more general equations. In the "long period" approach all short period effects are eliminated by analytical averaging before numerical integration.

This paper discusses a long period trajectory integration routine currently being developed to be interfaced with existing parameter estimation packages at LRC. (Aided by NASA grant NAS1-9434-44).

AN ANALYSIS OF PLANETARY EXPLORER CONTAMINATION PROBABILITY. Ronald H. Broadhurst*; Bird Engineering-Research Associates, Inc., Vienna, Virginia 22180.

This report presents a general discussion of the planetary quarantine problem for unmanned automatic spacecraft and uses the Orbiting Planetary EXPLORER Mission to Venus, as an example, to assess the probability of contamination. Probability formula are derived using simplified but sufficiently accurate approximations where expedient. The nature of microorganisms is discussed. Lander versus non-lander missions are compared and a method for generating a mission contamination model is presented. Aim point bias techniques are illustrated to reduce the mission contamination probability.

D-CYCLE: A NEW THERMODYNAMIC VAPOR CYCLE. THEORY AND POTENTIAL APPLICATIONS. J. G. Davoud* and J. A. Burke, Jr.* D-Cycle Power Systems, Inc., Richmond, Va. 23225

The D-Cycle is a condensing vapor thermodynamic cycle in which only a portion of expanded vapor (steam or certain

organic vapors) is condensed.

Condensate is injected as a mist into the remaining uncondensed vapor to lower the entropy and the wet vapor is compressed mechanically to operating pressure. The compressed vapor, which at this stage can be either wet, dry saturated, or superheated, is superheated to desired maximum temperatures. Thus D-Cycle has no boiler.

The D-Cycle is about 60% more efficient than the Rankine,

for steam at 1000 psia and 1000°F expanding to 40 psia--conditions suitable for an automobile.

A cycle, not an engine, the D-Cycle can be used in any form of expander-- reciprocating, positive displacement rotary, or turbine. Thus it is applicable as a basic prime mover to any power requirement. Suitable applications are portable electric generating sets for earth and space vehicles, boat and ship propulsion, automobiles, trucks, buses, off-road vehicles.

It results, with suitable (patented) compression equipment, in attractive efficiency increases in fossil-fueled, and especially nuclear, power plants.

LAMINAR BOUNDARY LAYERS ON SHARP AND BLUNT CONES AT ANGLE OF ATTACK IN SUPERSONIC STREAMS. M. C. Frieders* and C. H. Lewis, Aerospace Engrg. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Laminar boundary layers on sharp and blunt cones at angle of attack in uniform and nonuniform free streams were investigated. The inviscid flow fields over blunt cones were predicted from blunt body and three-dimensional method of characteristics solutions. Conical flow-field solutions were used for sharp cones in uniform streams, and threedimensional method of characteristics solutions were used for sharp cones in nonuniform free streams. A three-dimensional boundary-layer method was used to predict the viscous flows over sharp and blunt cones. The cases investigated include sharp cones in two-dimensional shear flows and in axisymmetric wake flows. Blunt cones were investigated in axisymmetric wake flows.

Results from the sharp and blunt cone cases are compared with available data. It is shown that heat transfer and skin friction increase along the windward streamline, even in the presence of an adverse pressure gradient. Data are also compared to a "small crossflow" model for sharp cones in wake flows to show the importance of the crossflow in the boundary layer and its effect on skin friction, heat transfer, and flow separation. (Supported by U.S. Air Force Contract F33615-70-C-1015).

DETECTION OF CONTAMINANTS ON SPACECRAFT MATERIALS. R. H. Honeycutt, III* and J. P. Wightman, Dept. of Chemistry, Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

Reflection infrared spectroscopy has been shown to be a convenient means of measuring both the kind and amount of contamination on solid surfaces. Silicone oil (DC-704) was chosen as a model contaminant for study on aluminum, germanium and KRS-5 (42 mole % thallous bromide - 58 mole % thallous iodide) surfaces. Known volumes of standard solutions of DC-704 in cyclohexane were introduced onto aluminum foils. The reflectance infrared spectra obtained for DC-704 on the three solids agreed with the transmission spectra of neat DC-704. An absorption peak at 1250 cm-1 due to the ≣Si-CH3 stretching vibration is unique for DC-704 Spectra were obtained at atmosphere and at pressures down to 10^{-8} Torr. The effects of elapsed time, pressure and temperature on the spectra were studied. [Work supported under NASA-Langley Master Agreement NAS1-10646].

NONEQUILIBRIUM BOUNDARY LAYER FLOW ON THE SPACE SHUTTLE

Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.
There is considerable interest in the nonequilibrium flow field around hypervelocity lifting reentry vehicles used in the space shuttle and outer space exploration programs, which spend an appreciable flight time at high altitudes. Nonequilibrium dissociation-recombination effects are important in determining vehicle aerodynamics, heat transfer and flow field ionization under these flight conditions While a good deal is now known about nonequilibrium effects in high speed two-dimensional or axisymmetric boundary layers, little has apparently been done in highly-three dimensional flows, especially those associated with lifting dimensional ritows, especially those associated with intern hypersonic vehicle configurations. In the case of flow around a swept wing, for example, a number of theoretical solutions are available for either perfect or equilibrium real gas flow but nothing for the situation where appreciable departures from dissociative equilibrium occur. first step toward dealing with nonequilibrium effects in general three-dimensional flows, the present paper analyzes these effects for the simpler but important case of laminar flow at the leading edge of a swept infinite span wing with a highly-cooled surface. The major purpose is to show the significant influence of cross flow on both the magnitude and basic nature of the nonequilibrium air reactions, including finite surface catalycity effects.

A NONLINEAR OSCILLATOR ANALOG OF RIGID BODY DYNAMICS. John L. Junkins, Ira D. Jacobson, <u>Jeffrey N. Blanton</u>. Deptof Aerospace Engineering, Univ. of Va., Charlottesville, Va.

Euler's equations governing the torque free motion of a general rigid body are classically solved in terms of elliptic functions. Due to the complexity of this solution, and to a general unfamiliarity with elliptic functions, it is desirable to use some dynamic analog to facilitate visualization of the important aspects of the rigid body motion. The most famous analog of this type is due to Poinsot and involves the inertia ellipsoid of the rigid body rolling on an invariant plane. This analog has several shortcomings including the lack of an explicit representation of time dependency.

It is shown that the motion of an arbitrary rigid body can be rigorously defined by three second order, nonlinear, uncoupled, ordinary differential equations of the Duffing
type. These three uncoupled differential equations are used to define a new motion analog consisting of three uncoupled nonlinear oscillators. Three associated phase planes are developed and discussed. The limiting cases and stability of the motion, as well as the time dependency, are readily seen in this phase plane representation.

CHEMICAL NONEQUILIBRIUM EFFECTS ON SUPERSONIC NOZZLE FLOWS AND FLAT-PLATE HEAT-TRANSFER. R. D. Kirchner*, A. K. Jakubowski* and C. H. Lewis, Dept. of Aerospace Engr., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A theoretical and experimental study of the effects of chemical nonequilibrium on supersonic air flows through a converging-diverging axisymmetric nozzle and along a flat plate has been made. The experiments were conducted in a NASA Langley arc-heated wind tunnel facility at exit Mach numbers of about 4 for a range of moderately low Reynolds numbers. Equilibrium, frozen and finite-rate nonequilibrium inviscid expansions were compared with experimental pressure data and reasonable agreement was obtained for the case of frozen and nonequilibrium flow calculations. Nonequilibrium stagnation heat-transfer predictions were found to be within about 10 percent of the experimental measurements. Nozzle boundary-layer calculations were made to determine the influence of viscous effects on the numerical predictions. Flat-plate boundary-layer calculations based on nonequilibrium, catalytic-wall conditions were found to be in close agreement with experimentally determined heat-transfer distributions. (Supported by NASA Grant NGR 47-004-070).

MOVING MASS ON PLATE. R. McNitt, and R. Raghavan*, Dept. of Engineering Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A theory describing the response of plate under a cyclic moving mass is developed. The theory based on Fourier

A theory describing the response of plate under a cyclic moving mass is developed. The theory based on Fourier transform technique shows that for a particular natural frequency associated with each mode of vibration of the plate, there are infinite number of mass movement frequencies that cause the instability of the system. The theory shows that for a simply supported plate, the resonance is reached prior by the moving mass system, than by the moving force system. The effects of the centripetal acceleration are also introduced and they are in the order of 10 to 15%. Numerical examples of typical deflection profile and instability curves are also presented.

TANGENTIAL SLOT INJECTION INTO SUPERSONIC TURBULENT BOUNDARY LAYER FLOWS. E. W. Miner* and C. H. Lewis, Aerospace Engrg. Dept., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

An implicit finite-difference method has been developed for solving the compressible boundary-layer equations with tangential slot injection. Effects of injecting air into supersonic turbulent boundary layers at Mach 2.4 and 6.0 are presented. Predictions of Mach number and pitot pressure profiles through the mixing region and wall skin-friction distributions are compared with experimental data and results of some other numerical solutions. Results of calculations made with the two-layer eddy viscosity models of Van Driest-Clauser and Van Driest-Schetz and the multi-layer model of Beckwith and Bushnell are compared with wall and profile data. The effects of pressure interaction on the wall skin-friction distribution downstream of the slot are discussed.

Good agreement was obtained for the reduction of wall skin friction with tangential slot injection. Comparison with experimental Mach number and pitot pressure profiles gave reasonable agreement in most cases. Calculations with the effects of pressure interaction included showed these effects to be smaller than the effects of changing eddy viscosity models. (Supported by NASA Grant NGR-41-004-072).

COMPARISON OF EXPERIMENTALLY DETERMINED PRESSURE COEFFICIENTS ON FLAT PLATES AND CYLINDRICAL BODIES INDUCED BY A JET IN A CROSS WIND. D.S. Ousterhout; Engineering Mechanics, Old Dominion University, Norfolk, Virginia 23508.

Norfolk, Virginia 23508.

An experimental investigation was undertaken to determine the surface pressure distribution on a flat plate and a cylindrical surface induced by a subsonic cold air jet exhausting normal to the surface and into a uniform free stream. The experimental data was obtained for a range of free stream velocity to jet velocity ratios between 0.3 and 0.7. The data is presented as plots of pressure coefficients as a function of a non-dimensional length parameter referenced to the jet location.

A comparison of the data obtained for the flat

A comparison of the data obtained for the flat plate and the cylinder indicated that: a) the influence of the jet-free stream interaction on surface pressure was damped out within approximately six nozzle diameters of the jet axis; b) the rate of pressure coefficient decay, in the free stream direction, was less for a cylindrical surface than the corresponding decay on a flat plate; c) jet induced increments of lift and pitching moments are influenced by the static jet dynamic pressure decay characteristics.

EFFECT OF AIR POLLUTION ON VISIBILITY AT NORFOLK, VIRGINIA.

W. M. Pritchard*, K. P. Chopra*, and P. M. Patel*. Dept.
of Physics, Old Dominion Univ., Norfolk, VA 23508
The east coast smog belt has expanded southward in

The east coast smog belt has expanded southward in recent years. It is the opinion of weather observers that a persistent haze has been present in the Hampton Roads area since about 1965 and has caused a significant decrease in visibility readings. An analysis is presented of the noon visibilities recorded on weekdays at the Norfolk Municipal Airport for the period 1960-1970. The mean annual visibility is found to have been slightly lower after 1964. No significant decrease appears to have occured in the annual frequency of visibility in the 12-15 mile range. However, the annual frequency of visibility in the 0-4 mile range increased by an average of 37 per cent after 1964. This effect may be attributed to an increase in atmospheric concentration of particulate matter.

TECHNOLOGY --- FOR A BETTER WORLD. <u>C. Raphael</u>*, Atlantic Research Corporation, Alexandria, Virginia 22314

It has become fashionable to criticize scientific development and to propose that the world stand still in the name of "ecology." But population is increasing, and people produce pollution, and they must be transported, and fed, and housed. Therefore we cannot stand still. We must recognize that the world is faced with problems of pollution, transportation, energy demand, natural resources depletion, hunger, and social conflict, and the only solution to our prosperous growth and survival is to solve all of these problems.

This paper discusses some of these problems and offers the alternatives for our ultimate fate: a Utopian worldwide community, or a starved, diseased, withering planet. If we accept the first and work toward its achievement, we have no alternative but to extend the frontiers of our knowledge, and to develop the communications satellites, the supersonic transports, the nuclear power plants, the automatic machinery, the high-protein rice, and the artificial hearts.

The presentation finishes with a short description of some of those programs which Atlantic Research is pursuing which will hopefully lead to a better world.

EXPERIMENTAL DETERMINATION OF THE NEUTRAL STABILITY CURVE FOR THE BOUNDARY LAYER OF A CYLINDER IN LONGITUDINAL FLOW. W.S. Saunders*, Dept. of Aerospace Engr., Univ. of Va., Charlottesville, Va. 22903

Dept. of Aerospace Engr., Univ. of Va.,
Charlottesville, Va. 22903

The boundary layer in the longitudinal subsonic flow about a cylinder was investigated using a hot wire anemometer. Vorticity perturbations were introduced into the boundary layer by applying an acoustic field to a sharp edge suction slot located near the leading edge of the body. The neutral stability curve was obtained by determining the points of maximum growth and decay of the perturbation. The results are compared to those obtained with a flat plate.

ESSENTIAL FEATURES OF INFRARED GASEOUS RADIATION AND RADIATIVE CONTRIBUTIONS FROM WEAK VIBRATION-ROTATION BANDS. S. N. Tiwari. Thermal Engr. Dept., Old Dominion Univ., Norfolk, $\overline{\text{Va.}\ 23508}$.

Analysis is presented to investigate the infrared radiative energy transfer in nongray nonisothermal gases under the conditions of non-local thermodynamic equilibrium. Attention has been directed to incorporate the spectral realities of vibration-rotation bands and to account for the variable (nongray) surface emittance in the governing integro-differential equations. Results are presented for CO, CO2, N2O, CH4, and H2O for the temperature and pressure range of 300-2000°K, and O.1-100 atmosphere respectively.

It is found that at a pressure of one atmosphere, the assumption of local thermodynamic equilibrium for a gas such as CO is not valid for temperatures below $600^{\circ}\mathrm{K}$, while for gases like CO₂ and N₂O, the assumption is justified at room temperature. Under optically thin conditions, where radiation depends solely upon integrated band intensity, the contributions from weak bands are not significant. However, under large path length conditions, where major portion of the band becomes opaque, the weaker bands have a significant effect upon the radiative transfer process within the gas. The influence of variable surface emittance upon radiative transfer ability of a gas is pronounced only in the large path length limit.

The feasibility of applying the present analysis to investigate the temperature distribution in the planetary atmosphere and to predict the concentration of major pollutants in the earth's atmosphere is discussed.

A NEW POLLUTION FREE TRACKED AIR CUSHION, AIR DRIVEN RAPID TRANSIT VEHICLE, Yau Wu., Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

A new concept of the linear air turbine vehicle is pro-

A new concept of the linear air turbine vehicle is proposed. The tracked air cushion and air driven rapid transit system is designed for the future high speed ground transportation in the urban area. Through the compressed air pipe lines to the passive vehicle, the system employes the principle of compressor, pipe, heating chamber, nozzle, turbine, air cushion and jet in a new combination. This vehicle contributes no air, thermal, vibration nor noise pollution. Many technical, environmental and economical problems have been discussed. The primary results indicate that this is indeed a very efficient, practical and economical system for the future high-speed ground transportation in the major cities.

NUMERICAL STUDY OF UNSTEADY BOUNDARY-LAYER SEPARATION. D. Th. <u>Tsahalis*</u> and D. P. Telionis, Va. Polytechnic Inst. and <u>State Univ.</u>, Blacksburg, Va. 24061

In reference [1] a theoretical study of the flow in the neighborhood of separation was presented. A modification of a numerical scheme developed by Werle and Davis [2] is presently used to verify the basic properties described in redifferential equation and the field data are stored for points in a plane (x,y), the 2-D flow field above a solid wall. Unsteadiness is introduced by letting $V_e = 1 + At^2x$ where V_e the free stream velocity t time and A a constant. Time is incremented and the plane (x,y) is sweeped again with time derivatives based on the stored information. It is thus indicated that for upstream motion of separation a point of zero skin friction is found with no evidence of singular behavior or any other properties usually accompanying separation. Downstream of this point a region of reversed flow is encountered and an upwind differencing scheme is used to continue the integration further downstream towards the station where the conditions for generalized separation (ref. [1]) are met. The basic conclusion is that the vanishing of skin friction or the appearance of reversed flow do not necessarily imply separation and hence termination of the boundary-layer integration in unsteady flows. 1. Sears, W.R., and Telionis, D.P., Proceedings of IUTAM Symposium, Canada, 1971. 2. Werle, M.J., Davis, R. T., J. Appl. Mech. ASME Conference 1971, No. 71-APM-31.

Section of Statistics

Fiftieth Annual Meeting of The Virginia Academy of Science May 3-5, 1972, Lexington, Virginia

SOME MULTIPLE SAMPLING PROCEDURES FOR CONFIDENCE INTERVALS. Robert L. Andrews, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A location parameter θ is restricted to some range (a,b), and the observable is distributed normally with mean θ and variance σ^2 . By assuming a uniform prior over the range (a,b) then the posterior distribution can be shown to be a function of the observable. To find a fixed width confidence interval with a minimum confidence for either σ^2 known or unknown then a multiple-stage sampling procedure is required.

MAXIMUM LIKELIHOOD ESTIMATION IN A PURE BIRTH PROCESS. R.W. Andrews* and R.G. Krutchkoff. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va.

In sampling without error at times t_1, t_2, \dots, t_n from a pure birth process with linear birth rate λ , the maximum likelihood estimator $\hat{\lambda}_n$ is found. Under restrictive conditions on the population size N₀ at time t₀ = 0, $\hat{\lambda}_n$ is shown to be consistent by using a theorem of Wald [Ann. Math. Stat., 1948]. In the case where N₀ is arbitrary but fixed it is shown that; for every $\epsilon > 0$, there exists a $\delta(\epsilon,N_0)$ such that

$$\lim_{n\to\infty} \mathbb{P}[|\hat{\lambda}_n - \lambda| > \varepsilon] \le \delta \le \frac{1}{N_0}$$

Data from brief simulation studies is also presented.

OPTIMAL KERNEL ESTIMATORS FOR THE DERIVATIVE OF A DENSITY. R.W. Andrews* and R.G. Krutchkoff. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24060.

In some empirical Bayes estimation problems a consistent In some empirical Bayes estimation problems a consistent estimate of the derivative of a density function is required. Such an estimate \mathbf{f}^1 (x) was proposed by Rutherford [Ph.D. Thesis, VPI&SU, 1967] based on the kernel estimates of the density proposed by Rosenblatt [Ann. Math. Stat., 1956] and extended by Parzen [Ann. Math. Stat., 1962]. The proposed estimate \mathbf{f}^1 _n(x) depends on two sequences of constants h(n) and h*(n). Based on minimizing $\mathbf{J} = \mathbf{E} \int_{\mathbf{X}} (\mathbf{f}^1 \mathbf{n}(\mathbf{x}) - \mathbf{f}^1(\mathbf{x}))^2 \mathrm{d}\mathbf{x},$

$$J = E \int_{\mathbf{x}} (f'_{n}(\mathbf{x}) - f'(\mathbf{x}))^{2} d\mathbf{x},$$

the mean integrated squared error (MISE), values for h(n)and $h^*(n)$ are found which depend on n, the sample size and σ^2 , the variance of the underlying density.

CLASSIFICATION IN PSYCHIATRY. John J. Bartko*. Nat. Inst. of Mental Health, NIH Campus, Bldg. 36, Room 1D-15, Bethesda, Marvland 20014

Cluster techniques may possibly contribute to the improvement and development of methods used in the classification of psychiatric patients. However, numerous problems and complexities are encountered in attempting any cluster analysis. These include lack of a definition of a cluster, choice of input data format, choice of similarity measure, selecting a clustering algorithm, and deciding how many groups there are in the data. Because of these basic difficulties, several strategies are presented for undertaking a cluster analysis as well as a comparison of some cluster techniques applied to Archetypal psychiatric patient data. The reproducibility or persistence of the Archetypal data clusters as well as the persistence of cluster results obtained with real psychiatric data is discussed. The validation of psychiatric clusters by comparison to external criteria, outcome status and the relationship of the problem to quasi-retrospective studies is touched upon.

THE DISTRIBUTION OF CARDIAC ARRESTS - ANOTHER VERSION OF THE BIRTHDAY PROBLEM. W. H. Carter, Jr., Department of Biometry, Medical College of Virginia, Richmond, Virginia 23219

The value of organized programs in cardiopulmonary resuscitation is well established. Within most, if not all, hospitals, teams of trained individuals are formed to respond to cardiopulmonary arrests. In addition to their special training, the team requires the use of much expensive and sophisticated equipment. Most hospitals maintain more than one complete team in order to be prepared to respond to a second arrest while the first arrest is in progress, or while the equipment used for the first arrest is being replenished. As a result, there is a problem associated with the determination of how many teams a hospital should maintain, especially since the personnel and equipment necessary for such teams is expensive.

In this paper, we develop the mathematics necessary to allow administrators of health centers to calculate the number of times multiple arrests can be expected to occur within a time interval short enough to necessitate maintaining more than one cardiopulmonary resuscitation team. The results are then applied to the experience at the Medical College of Virginia.

ORTHOGONAL CONTRASTS AND THE GENERALIZED INVERSE IN FIXED EFFECTS ANALYSIS OF VARIANCE. W. H. Carter, Jr. Dept. of Biometry, Medical College of Virginia, Richmond, Va. 23219 and R. H. Myers, Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, Va. 24061

Recently there has been a tendency to present textually the theory of less than full rank linear models through the use of the generalized inverse matrix. The difficulty that students often encounter in the use of the generalized inverse in a theoretical linear models course is visualizing its relationship to other concepts to which they were exposed in earlier courses.

posed in earlier courses.

In this paper, a method of constructing generalized inverses for the X'X matrix resulting from one and two way fixed effects analysis of variance models (without interaction) is developed. This method employs the use of orthogonal contrast constants. An interesting result is that the orthogonal contrast constants are elements of the eigenvectors associated with the characteristic roots of X'X.

AN ECONOMICALLY OPTIMAL MARKOVIAN SAMPLING POLICY FOR MONITORING CONTINUOUS PROCESSES. J. R. Crigler* and J. C. Arnold, Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24,061

A sampling procedure for monitoring the outgoing quality of a continuous process over T time units is considered.

A sampling procedure for monitoring the outgoing quality of a continuous process over T time units is considered. The procedure permits k acceptance levels and uses a variable sampling ratio, sampling less frequently when the process is in control. The sampling procedure is formulated as a simple Markov process. The types of continuous processes to which the procedure is applicable are discussed.

A method for choosing economically optimal sampling policies is covered. An objective function is presented which incorporates both a sampling cost and a penalty cost associated with sensitivity criteria. The objective function is flexible in the sense that it permits the monitoring agency to choose its own cost and sensitivity restrictions. Optimization is attained by application of the technique of dynamic programming. An example illustrating a possible application of the procedure is presented.

SOME THEORETICAL ASPECTS OF RANDOM EQUATIONS OF EVOLUTION IN THEORETICAL POPULATION GENETICS.
A. I. Dale and K. Hinkelmann. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

The fundamental step in the evolution of a population, as far as its genetic make-up is concerned, is change in gene frequency. This change may conveniently be regarded as a continuous stochastic process satisfying the Kolmogorov forward equation.

Two evolutionary processes involving genic selection are considered, one for a finite population, the other for an infinite population. Certain coefficients in the resulting partial differential equations are considered to be random variables as is suggested by practical considerations. This then gives rise to random partial differential equations. Various methods of solving these are investigated and the results are compared with the deterministic solutions.

A "MAKE OR BUY" MODEL FOR AMMUNITION. I. A. DeArmon, Jr., US Army Munitions Command, Operations Research Group, Edgewood Arsenal, Maryland 21010

The cost of procuring ammunition from contractor-owned sources (COCO) versus the cost of this procurement from Government-owned plants (GOCO) was assessed. Claims that industry could accomplish the task at considerable dollar savings to the Government either for operations over a long period of years or for a single year's procurement were evaluated. Two models were developed.

The first model was a generalized total cost model, which provided a means of comparing the total cost of ammunition procured from either a hypothetical COCO plant or from a GOCO plant. The second model, called the Multiple Bid Evaluation Model, used in conjunction with the total cost model, was developed for obtaining a minimum cost solution when a specific item might be procured on a one-time basis from a combination of both COCO and GOCO bidders. Several applications were made to demonstrate the utility of the models.

The total cost model was used to compare COCO and GOCO costs, based on historical and hypothetical plant costs, over an extended period. Break-even analyses were conducted to demonstrate trade-off features between COCO profit margins and plant efficiencies and to illustrate break-even points. The Multiple Bid Evaluation Model was applied to a single procurement action of a specific item to determine the minimim cost of bid quantity options from COCO and GOCO suppliers.

MULTISTEP THEORY - APPLICATION TO SECTIONING AND PATTERN SEARCH. J. B. Foster, R. W. Lane, and W. C. Turner, Dept. of Industrial Engineering and Operations Research, Va. Poly. Inst. and State Univ., 24061.

Most directional search procedures develop a program of "better points" where each is an optimum for the given direction at that stage. Recently, it has been shown that the choice of other than optimum points and the simultaneous determination of several steps can implore the rate of convergence. These concepts can be lumped together as "multistep" procedures.

The rate of convergence becomes extremely important when functional evaluations are costly as when experimental results or simulation runs are involved. Usually derivatives are not readily available in these situations so sectioning or pattern search seem appropriate. This paper discusses the use of multistep theory to improve the rate of convergence of sectioning and pattern search on several test functions chosen for their range of diversity.

MULTIPLICATIVE CONGRUENTIAL PSEUDO-RANDOM NUMBER GENERATION ON THIRD GENERATION BINARY COMPUTERS. R. A. Gaskins. Dept. of Math. and Comp. Sci., H-S Col., Hampden-Sydney, Va. 23943

A popular method for producing pseudo-random numbers by computer is to use the method

$$x_{n+1} = ax_n \pmod{m}$$

because, if m is chosen as the natural modulus of

because, it m is chosen as the natural modulus of a binary computer having b bits, this method is very fast. The modulus of such a computer is 2 The most widely known and used generator is RANDU (IBM 360 SSP Version III), but it is constructed in such a way that it ignors the b-th bit at the expense of running time and cycle length. Faster generators can be constructed if the natural modulus is used instead. For example, for the IBM 360 or 370 computer (b=16)
FUNCTION RAGDU(IX)

IX=IX*65543 RAGDU=IX*.2328307E-9 RETURN END

which is written in FORTRAN IV, will simulate the same uniform distribution as RANDU but shifted 1/2 unit to the left, i.e. (-.5, .5).

GLOBAL NONPARAMETRIC ESTIMATION OF PROBABILITY DENSITIES. I. J. Good, Dept. of Statistics, Va. Polytechnic Inst. & State Univ., Blacksburg, Va. 24061; and R. A. Gaskins, Dept. of Mathematics, Hampden-Sydney College, Hampden-Sydney, Va. 23943

Given a number of observations x_1, \ldots, x_N , a nonparametric method is suggested for estimating the entire probability density curve. The method is to subtract a roughness penalty from the log likelihood, where the roughness penalty is a certain functional of the assumed density function f. Those used are linear combinations of $\int \gamma^{-2} dx$ and $\int \gamma^{u^2} dx$, where $\gamma = \sqrt{f}$. The method appears to be consistent under wide conditions, although consistent methods can be rough. Numerical examples are given and show that for certain values of the coefficients in this linear expression the density function $% \left(1\right) =\left(1\right) +\left(1\right) +\left($ turns out to be very smooth even when N is small. Multivariate extensions are proposed, including one to distributions having some continuous and some discrete components, but numerical examples of these have not been tried. Some of the techniques are borrowed from quantum mechanics and tensor calculus.

OPTIMAL HIERARCHIAL FACTORIAL DESIGNS: THE MULTIPLE DESIGN MULTIRESPONSE CASE WITH COST CONSTRAINT, Samuel V. Givens* and Klaus H. Hinkelmann. Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061.

In designing multivariate experiments it will often be the case that different responses have

different design matrices. This most often occurs when certain responses are not influenced by various factors. If not all responses are measured on each observational unit then this gives the more general linear multiresponse (MGLM) design.

For a factorial experiment denote by V a variance-covariance matrix of estimable functions of the main effect parameters for all responses. Optimal size designs are found that minimize the Optimal size designs are found that minimize the trace of V when the size of the design is restricted by a total cost constraint. It is shown that hierarchial MGLM designs, a subset of the MGLM designs, need only be considered. Given that the costs and 'a priori' estimates of the variances are known, the number of observations can be determined for each response in the design which

is optimal with respect to the trace criterion.
Similar results hold when using minimization of
the determinant as the criterion for optimality rather than the trace.

SOME BIVARIATE NEGATIVE BINOMIAL DISTRIBUTIONS.

J. W. Hall. * Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061 A review of past work in the definition of bi-variate negative binomial distributions indicates that in every case the univariate marginal distrithat in every case the univariate marginal distributions have the same coefficient of dispersion. Some unpublished data on fish movements provides a motive for deriving bivariate negative binomial distributions whose marginal distributions have unequal coefficients of dispersion. Three different methods are used to produce such distributions and the results are compared and the results are compared.

SOLUTIONS TO STOCHASTIC INTEGRAL EQUATIONS USING THE RESOLVENT KERNEL APPROACH. S. Hardiman* and C.P. Tsokos* Dept. of Statistics, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061
This paper demonstrates the resolvent kernel

approach for obtaining a random solution, a second order stochastic process, for nonlinear stochastic Volterra type integral equations

 $x(t;\omega)=y(t;\omega)+\int_0^t k(t,\tau,x(\tau;\omega);\omega)f(\tau,x(\tau;\omega))d\tau$ and

 $\mathbf{x}\left(\texttt{t};\omega\right)\!=\!\!\mathbf{y}\left(\texttt{t};\omega\right)\!+\!\mathbf{h}\left(\texttt{t},\mathbf{x}\left(\texttt{t};\omega\right)\right)$

+ $\int_{0}^{t} k(t,\tau,x(\tau;\omega);\omega) f(\tau,x(\tau;\omega)) d\tau$

 $+ \int_0^x (t,\tau,x(\tau;\omega);\omega) f(\tau,x(\tau;\omega)) d\tau$ for termular equations for the standard equations for the standard equations and the standard equations for the standard equations a random solution, prove that it satisfies the stochastic equation if $y(t;\omega)$ is a process continuous in mean square and that the series representation converges in mean square to $x(t;\omega)$.

THE GENERAL N-COMPARTMENT MODEL FOR ANALYSIS OF FLOWS IN BIOLOGICAL MEMBRANES. J. R. Howell, Department of Biometry, Medical College of Virginia, Richmond, Virginia 23219
A compartment is defined by a characteristic material

that occupies a given volume, e.g., medicine in the stomach.

The mathematical description of biological processes by means of tracers is called compartment analysis. These processes are represented by systems of first-order, linear, ordinary differential equations with constant coefficients, where there is one such differential equation for each compartment. If there is diffusion or flow between compartments, we have a compartment system.

Consider an n-compartment system with two-way diffusion between all compartment pairs, with "leaking" from every compartment, and an initial amount of substance in each compartment at time zero. An algorithm is given for writing the equations associated with such a system and a solution is shown. An analog computer diagram is shown which yields numerical solutions to these differential equations, hence provides a model for studying the system for different values of the parameters.

Finally, the estimation of these parameters by use of analog and digital computers is discussed. (Aided by NIH Grant Number RR00016)

COMPITTERIZED FLOWS OF RADIOACTIVITY IN A MILITICOMPARTMENT SYSTEM SIMULATING Na+ FLUXES IN FROG SKIN EPITHELIUM. E. G. Huf, Departments of Physiology and Biometry, Medical College of Virginia - VCU, Richmond, Virginia 23219

In studies on the kinetics of flow of salt across an epithelial membrane, frog skin has long been used as a model membrane to study the movement of Na^+ ions, a "backbone" ion in the physiological electrolyte structure. The flow of Na^+ across this multicellular epithelial structure is governed by both "passive" diffusion processes and an "active" Na+ transport mechanism. At least 3 separate compartments are histologically identifiable. When one outside, and one inside fluid compartment are added in a double chamber system, with the isolated skin separating the two fluid compartments, one deals with a 5-compartment system. The purpose of this paper is twofold; 1) to present evidence for the assumption of a 5-compartment system, 2) to apply mass-law kinetics to the transmembrane flow of Na⁺ in the forward and backward direction, applied to "normal skin", and skins under the influence of hormones and drugs known to alter membrane permeability and active transport forces. Five linear differential equations can be written, but data in all compartments are not available for estimating the parameters. However, a computer simulation program was applied to find parameters such that solutions are in general agreement with a large body of experimental facts. Computer results from varying these parameters suggest several new

AN ANALYSIS OF THE BED ALLOCATION PROBLEM. John E. Jackson*, and John A. White. Dept. of Ind. Eng. and Op. Res., Va. Polytechnic Inst., Blacksburg, Va. 24061

The problem of optimally allocating the bed resources of

a hospital among several patient services is subjected to quantitative analysis in this paper. Four patient services are considered. Based on the result of an investigation of the bed allocation problem within four small to medium sized hospitals, an analytic model is developed to assist the hospital administrator in the allocation of beds. The objective is taken to be the minimization of the expected daily cost of patients not being admitted to their desired service. A dynamic programming solution is obtained and sensitivity analyses performed.

ON BIASED ESTIMATION IN LINEAR MODELS.

types of laboratory experiments.

ON BIASED ESTIMATION IN LINEAR MODELS.
Lawrence S. Mayer* Va. Polytechnic Inst. and State
Univ., Blacksburg, Va. 24061. Thomas A. Willke*
Ohio State Univ., Columbus, Ohio.
Hoerl and Kennard introduced a class of biased
estimators (ridge estimators) for the parameters
in an ill-conditioned linear model. In this
paper the ridge estimators are viewed as a subclass of the class of linear transforms of the
least squares estimator. An alternative class of least squares estimator. An alternative class of estimators, labeled shrunken estimators is considered. It is shown that these estimators satisfy the optimality condition proposed by Hoerl and Kennard. In addition, both the ridge estimators and shrunken estimators are derived as minimum norm estimators in the class of linear transforms of the least squares estimators. The former minimizes the Euclidean norm and the latter minimizes the design dependent norm. The class of estimators which are minimum variance linear transforms of the least squares estimator is obtained and the members of this class are shown to be stochastic shrunken estimators. An example is computed to show the behavior of the different estimators.

INVARIANT ESTIMATION IN SOCIAL SCIENCE MODELS. L.S. Mayer*, Dept. of Statistics and Mary Sue Younger*, Dept. of Business Administration, Va. Polytechnic Inst. and State Univ., Blacksburg, Va. 24061

A problem found quite often in social science literature is that of estimating the parameter $\theta=(\underline{\beta},\sigma^2)$ in the linear model $\underline{y}=\underline{X}$ $\underline{\beta}+\underline{\epsilon}$ in a manner invariant under changes of scale on the independent and dependent variables. The invariant estimator commonly used is called a "beta coefficient" or "standardized regression coefficient."

In this paper we attempted a rigorous formulation of the "beta coefficient." The appropriate invariant estimation problem was defined and an invariant sufficient estimator was obtained. This estimator is not the same as the "beta coefficient" used in the social sciences; thus we concentrated on a comparison of the usual social science estimator with the invariant sufficient estimator we obtained.

We found that the invariant sufficient estimator is superior to the usual estimator in terms of such criteria as sufficiently, unbiasedness, consistency, and simplicity of distribution.

A STOCHASTIC MODEL FOR CHEMICAL KINETICS. <u>J. Susan Milton.</u>* Dept of Statistics, Radford Col., Radford, Va. 24141. A stochastic model for chemical kinetics is proposed

where for each t $\xi(t;\omega)$ is an unknown R dimensional random variable representing the "extent of reaction" at time t is presented. The mathematical theory necessary to study questions of existence and uniqueness of a random solution to the above random equation is developed using the techniques of probabilistic functional analysis the theory of admissibility.

COMPUTATION OF PARTIAL GAMMAS FROM PRODUCT MOMENT LOGIC. B. Krishna Singh, Dept. of Sociology, Virginia Commonwealth University, Richmond, Va. 23220

Davis (1967) suggests a way of computing partial gammas following the measure based directly on probability of error of ordered polytomies. This technique (1) is an overestimate and (2) is cumbersome to calculate when the ordered polytomies are not either dichotomies or trichotomies. This paper provides a proof for the computational formula of:

amount of variance explained in two ordered polytomies (x,y) when the effects of a third ordered polytomy (z) are partialled out. An illustrative exampls is given.

A BETA DISTRIBUTION APPROACH TO DIAMETER CLASS FREQUENCIES IN LOBLOLLY PINE STANDS. M. R. Strub*. Division of Forestry and Wildlife Sciences, VPI & SU,

Blacksburg, Va. 24061.

Efficient utilization of forest land requires knowledge of stand characteristics such as the distribution of tree diameters. Two hundred and forty one-tenth acre sample plots were taken in loblolly pine (Pinus taeda) plantations located in piedmont and coastal plain Virginia, Delaware, Maryland and North Carolina. Tree diameters were grouped into one-tenth, one, and two inch class intervals. In each case the beta distribution was fitted to the data by the methods of maximum likelihood and moments. Estimates of the parameters of the beta distribution, as well as minimum and maximum diameters, were correlated to the stand parameters, age, average height of the dominant stand, and number of trees per acre. The resultant diameter class frequencies for each class interval-parameter estimate combination were compared to the original data. Recommendations concerning class interval and parameter estimation technique for diameter frequency prediction were made.

THE ECONOMIC OUTLOOK. <u>Leland E. Traywick</u>. Dir., Bur. Bu Res., Col. Wm. & Mary, Williamsburg, Va. 23185. After a winter of some discontent, the economic indica-Dir., Bur. Bus.

tors are blooming along with spring and robins in the first quarter's reports. The leading economic indicators have been forecasting this for some months and recently turned up sharply. The coincident indicators confirm the predictions. Among these that are most carefully watched are the Federal Reserve's index of industrial production (up 7.3 percent annual rate in March), retail sales (up 8 percent over a year ago), new housing starts (strong at a 2,66 million annual rate in Feb.--down a bit because of shortages in March), expenditures planned for capital improvements stand at an increase of 10.5 percent (was 1.9 percent in 1971), and all of the surveys show a decided increase in business and consumer sentiment for the remainder of this year. If the bright expectations are reached, GNP could increase by some \$100\$ billion as forecast earlier--a great vintage year.

Some drags on the economy occur. One is a threat of inflation. Wholesale prices jumped 10-12 percent early in the year. Grocery prices roared up at a 24 percent annual rate in February. The fiscal federal deficit, although expected to be \$30 billion instead of \$39 billion, still is considered inflationary. Meanwhile the Federal Reserve increases the money supply at a 10.9 percent rate. Unemployment remains high inspite of increases in actual employment. The international unrest and the failure of dollar devaluation

keep alive a decided balance of payments deficit.

ESTIMATING PARAMETERS IN MICHAELIS-MENTEN KINETICS. W. A. Wiegand*, and R. E. Flora, Dept. of Biometry, Medical Col. of Va., Va. Commonwealth Univ., Richmond, Va. 23219

General development of Michaelis-Menten kinetics equation is given followed by some popular techniques used to linearize the model. It is pointed out that statistical problems arise concerning the experimental error when these techniques are used in conjunction with linear least squares to estimate the parameters V_{max} and k_m . Weighted nonlinear least squares is also discussed.

Development of the maximum likelihood estimates for V max, k and the variances is given. Discussion of the likelihood ratio test and its application to the problem of determining whether two dose-response curves are the same or alternatively represent competitive, noncompetitive or mixed inhibition are included.

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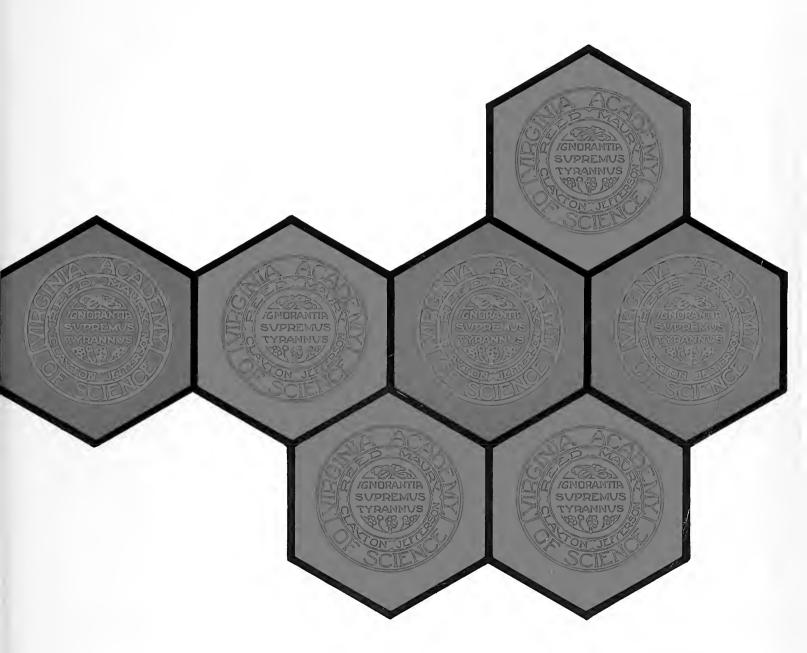
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The front cover is by Douglas C. Hensley.

Semi-Centennial Celebration of the Virginia Academy of Science College of William and Mary Williamsburg, Virginia May 2, 1973

The Virginia Academy of Science will return to the College of William and Mary in Williamsburg, Virginia, on Wednesday, May 2, 1973, to commemorate its founding there fifty years ago. This special celebration will open a three-day session for the Senior Academy. The Junior Academy will have convened several days earlier.

The period, 1923-1973, represents the great awakening of science in Virginia. This program on May 2 will highlight the great part that the Virginia Academy played in this renaissance of science. It will recognize some of the leaders, note a few of the major contributions to science by its members, and indicate the growth of the Academy both in membership as well as papers submitted at the annual meetings. A glimpse of the future of the Academy will be unveiled.

The great impact that the Academy has had on science and higher education will be featured at the

evening meeting.

The leading role that the Academy has had in encouraging the juniors by its Science Talent Search as well as the Junior Academy will be described. Following is the program adopted by the Ad Hoc Committee for the celebration.

Program

May 2, 1973, 1:30 p.m.-10:00 p.m.

The Welcome

Dr. Thomas Graves, President of the College of William and Mary

Dr. Carlisle Humelsine, President of Colonial Williamsburg

Response

Dr. Franklin Flint, President of the Virginia Academy of Science

Early History of the Virginia Academy of Science Dr. I. D. Wilson, President of the Academy, 1931–

Emeritus Professor, V.P.I. & S.U. 30 minutes

Introduction of all living ex-presidents and charter members of the Academy with comments

Dr. Walter S. Flory, President of the Academy, 1955-56

Wake Forest University 20 minutes

Introduction of the J. Shelton Horsley Award Winners and the Jefferson Award Winners

Dr. Dexter Whitehead, University of Virginia 15 minutes

Introduction of the Virginia Academy of Science Meritorious Service Award Winners

E. S. Harlow, President of the Academy, 1956–57 American Tobacco Company, retired 10 minutes

Introduction of the former editors of the Virginia Journal of Science with a short history of the publications of the Academy

Dr. Boyd Harshbarger, President of the Academy, 1949-50 V.P.I. & S.U. 10 minutes

History of the Science Talent Search E. V. Russell, V.P.I. & S.U. 10 minutes

History of the Junior Academy Mrs. Vera Remsburg, Herndon High School 10 minutes

Growth of the Academy and Its Future Dr. Franklin F. Flint, President of the Academy, Randolph-Macon Woman's College 30 minutes

6:45 p.m. Banquet

8:00 p.m. Evening Meeting Impact of the Virginia Academy of Science on Science and Higher Education in the State Over the Past 50 Years

Dr. W. T. Sanger, President of the Academy, 1934-35

> Chancellor-Emeritus of the Medical College of Virginia

VIRGINIA JOURNAL OF SCIENCE

This issue completes Volume 23 of the *Journal*, and the Editor wishes to take this opportunity to express his sincere appreciation and gratitude to all who have assisted him with the *Journal* during the past 4½ years. He also extends best wishes to the new Editor, Dr. Charles O'Neal, who will continue to have the able assistance of Business Manager Dr. Charles O'Rear. In addition Dr. Edward Bowman will serve as Advertising Manager to try to decrease the cost of the *Journal* to the Academy by increasing advertising revenue.

For a number of years the Virginia Academy of Science has subsidized about half the cost of publishing and distributing the *Journal* as an important part of its contributions to science and scientists in Virginia. Increasing costs have reached the point where each volume of the Journal costs approximately \$6.00 per member while dues per member are only \$5.00. For this reason the Publications Committee has recommended to the Finance Committee that the annual dues to members be increased and that subscription rates to libraries, etc. be raised \$2.00 per year from the present rates of \$8.00 for domestic

subscriptions, \$8.50 per year for Canada and other Pan-American countries and \$9.00 per year for all other foreign countries.

The Publications Committee recognizes the importance of maintaining the quality of the Journal, and the Academy plans to continue to subsidize part of the cost. All members who can afford to upgrade their membership classification (e.g., contributing \$15.00) are urged to do so. The addresses of the new

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Global Nonparametric Estimation of Probability Densities

Summary

Given a number of observations $x_1 \cdots, x_N$, a nonparametric method is suggested for estimating the entire probability density curve (although a parametric method is also briefly mentioned). The method is to subtract a roughness penalty from the log-likelihood, where the roughness penalty is a certain functional of the assumed density function f. The penalties used are linear combinations of $\int \gamma'^2$ dx and $\int \gamma''^2 dx$, where $\gamma = \sqrt{f}$. The method is consistent under wide conditions, although consistent methods can be rough. Numerical examples are given and show that for certain values of the coefficients in the linear expression the density function turns out to be very smooth even when N is small. Multivariate extensions are proposed, including one to distributions having some continuous and some discrete components, but numerical examples of these have not been tried. Some of the techniques are borrowed from quantum mechanics and tensor cal-

* This paper, which was invited by the editor, consists of a reprinting of Good and Gaskins (1971b), together with several additions, and we are grateful to the Biometrika committee for permission for the republication. Each addition to the original version, apart from a few very minor ones, has been enclosed between a pair of asterisks, and the original hypallagous title has been changed to avoid confusion of the two versions.

We have now found that the techniques previously described can be readily adapted to deal with data given in histogram form, a fact that makes the work applicable, for example, to a common form of data occurring in high-energy physics.

We shall report some new extensive sampling ex-

periments for selecting roughness penalties in terms of goodness of fit to known populations, and an iterative method will be described for the selection of the roughness penalty when a sample is given. In the earlier work, the selection of the roughness penalty depended mainly on the smoothness of the putative density function as estimated by eye.*

Preface

* The British statistician George Barnard once remarked that he thought the notion of a histogram is the most important one in statistics. Since a histogram is virtually an estimate of a density function it is not surprising that the literature on density estimation is large. The method described in the present work, which can be applied both to histograms and to raw data from which histograms are often constructed, is the only method known to us with a Bayesian interpretation applicable when the true density is not assumed to belong to a specified parametric family. But the method can also be used, up to a point, without a Bayesian interpretation, and thus provides an example of the Bayesian influence for a classical problem in statistics that Barnard at least might consider to be the most important one. From a fundamental point of view it is very interesting to see a marriage of the two main conflicting schools of statistics occurring in so central an area. For it verifies that a synthesis of the Bayesian and non-Bayesian points of view, which has been repeatedly emphasized by one of the present writers, is breaking through to a new level of maturity.

To prevent misunderstandings we add that the expression "Bayesian" has many shades of meaning, and much controversy arises through overlooking this. Here we shall not discuss this semantic issue, but we refer the reader to Good (1972) which was intended to be only slightly facetious.

This work is not only a wedding of Bayesian and non-Bayesian methods; it is also a wedding of philo-

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sophical and numerical methods, of theory and practice, and in some ways of statistics and physics. But a wedding is not the whole of a marriage, and the future may reveal the full fruitfulness of these unions.*

1. Introduction

A fundamental problem is statistics is the estimation of a density function from a sample of observations. An example of a useful but not very familiar application would be for the estimation of probability densities of discriminant functions. This could be used, for example, for choosing between treatments when a discriminant function is available for success and failure in regard to each treatment. Another kind of application is for deciding whether a bump in the apparent density function is genuinely in the population, or more generally for deciding whether one density function is a better estimate than another one and by how much. According to Orear & Cassel (1971), 'bump hunting' is one of the major current activities of experimental physicists, and they requested aid from statisticians. When a bump is not due to random variation it is usually due to a new elementary particle or resonance.

The method of estimating a density function to be discussed in this paper arose from a proposal of Good (1971a, b) and is here modified, developed further, and exemplified numerically and graphically. A multivariate extension is proposed but no multivariate numerical calculations have yet been done. *Note that the problem of bump detection is not precisely the same as that of density estimation, for bump detection is not a pure estimation problem.*

2. The Basic Approach

For the estimation of a density function f of a random scalar or p-dimensional vector, \mathbf{x} , given N observations $\mathbf{x}_1, \dots, \mathbf{x}_N$, the likelihood or its logarithm

$$L = \sum_{i} \log f(\mathbf{x}_{i}) \tag{1}$$

is relevant; but a naïve application of maximum likelihood methods would make the estimate the mean of a set of Dirac functions at the N observations. *Nobody accepts this solution because it is too rough. Also it has no predictive value since it is almost certain that the next value of x will be one that has never occurred before. (For the one-dimensional case, the integrated form is the step function usually described as the empirical distribution function, as used in the Kolmogorov and Smirnov tests. The discussions of these tests in the literature do not, as far as we know, mention the maximum-likelihood estimate of the density function, possibly because of its absurdity.)* It must be better to subtract a penalty for roughness from the log likelihood before maximizing. Accordingly our basic approach is to maximize a score ω , depending on f, \mathbf{x}_1 , \cdots , \mathbf{x}_N , and defined by

$$\omega = \omega(f) = L - \Phi(f), \tag{2}$$

where the *roughness penalty* Φ is a functional $\Phi(f) = \Phi\{f(\cdot)\}$ of f. Of course L too is a functional of f but

it depends on the observations in addition. Note the mnemonics that ω is for 'overall score' and Φ is for 'flamboyance functional,' flamboyant in the sense of having a wavy edge.

Although this approach seems reasonable from a non-Bayesian point of view, it was proposed for a Bayesian reason, and the Bayesian interpretation has the advantage that it gives some measure for how much better one density function f is than another one. It thus contributes to bump theory.

A full-dress Bayesian approach would involve the maximization of the expected utility of an assumed f. One would need, among other things, a formula for the utility of assuming one density function when another one is true, as discussed by Good (1968b, 1969). Such an approach would be very complicated so we use only a Bayesian approach in mufti, in which the aim is to maximize the final density of f in function space. This is analogous to a familiar method for estimating a scalar or vector, of which the ordinary method of maximum likelihood is the special case where the prior is uniform. A uniform prior in function space is out of the question, and would lead to the Dirac catastrophe mentioned before. The prior density in function space implied by (2) is proportional to

$$e^{-\Phi}$$
. (3)

When this Bayesian approach is used, with a specific functional, the final log odds in favour of one density function f_1 as compared with another one f_2 is

$$\omega(f_1) - \omega(f_2)$$
 natural bans, (4)

where a natural ban is the unit suggested in 1940 by A. Turing for log odds and 'weights of evidence' when the base of the logarithms is e. For the bases 2, 10, $10^{0.1}$ and $10^{0.01}$, the unit is a bit, a ban, a deciban and a centiban, respectively, and so on.

When the aim is merely to obtain the 'best' smoothing, the Bayesian interpretation can be ignored.

The choice of the penalty functional Φ will be considered in §5, and, for the multivariate case, in §9. Section 10, on invariance, is relevant to both cases. We shall always assume that

$$\Phi(f) \ge 0, \tag{5}$$

whenever $\Phi(f)$ is defined, and that

$$\Phi(f_0) < \infty \tag{6}$$

for the true density f_0 . We do not rule out infinite values for $\Phi(f)$, but such f's will score minus infinity so they will rule *themselves* out.

Density estimation is probability estimation for continuous distributions. For discrete distributions an analogue of a roughness penalty was proposed by Good (1963, p. 931; 1965, p. 76), namely the entropy, as a generalization of the principle of maximum entropy. The entropy seems inappropriate for continuous distributions because they could have violent small ripples with little affect on the entropy,

and it is better that Φ should depend on the derivatives of f. For multivariate distributions with some continuous and some discrete components, see §9.

3. Consistency

We shall give a 'physicist's proof' of the following theorem. A rigorous proof might require a further constraint on the allowable density functions. *The proof now seems rigorous to us, although the details are not all explicit.*

THEOREM. Suppose that we consider only those density functions that are continuous, and satisfy the the condition

$$\int f(\log f)^2 dx < \infty. \tag{7}$$

Then the estimate f, obtained by maximizing ω , is consistent in the sense that in probability

$$\int_{b}^{a} f(x) dx \longrightarrow \int_{b}^{a} f_{0}(x) dx, \tag{8}$$

whenever b < a, where f_0 is the true density function. Unspecified ranges of integration are taken to be $(-\infty, \infty)$. Consistency does not imply the absence of false bumps: they could become small and nu-

merous as N increases.

Proof. To prove this, note that, by (5), in a sample of N observations,

$$E(\omega(f_0) - \omega(f)) \ge N \int f_0(x) \log \frac{f_0(x)}{f(x)} dx - \Phi(f_0).$$
 (9)

The integral here is an "expected weight of evidence per observation" and we denote it by W (see Section 6). It is non-negative and can vanish only if $f = f_0$. Moreover, if we assume

$$\int f_0(\log f)^2 dx < \infty, \qquad (7A)$$

and we shall come back to this, the standard deviation of L is $O(\sqrt{N})$ so that, by Chebychev's inequality, in probability $\omega(f_0) - \omega(f)$ is ultimately positive. Therefore, by (6), in probability, any specified $f \neq f_0$ is ultimately beaten by f_0 when N is increased. In a large sample, in probability, those fs that are not yet beaten will have the integral W negligibly small so that the limit in (8) is true in probability.

Although (7A) does not follow from (7) it fails to follow only in virtue of the possibility that f is much smaller than f_0 at infinity. If f is replaced by another density function f^* for which this is not true, in which f is slightly increased at infinity and slightly decreased elsewhere, the expression $\omega(f_0) - \omega(f^*)$ will be almost the same as $\omega(f_0) - \omega(f)$ or will be smaller, whereas condition (7A) will be true with f replaced by f^* . This justifies us in assuming (7A) in the course of the proof. Another point we have slurred over is that, under condition (7A).

$$\left(\int f_0 \log f \, dx\right)^2 = \left(\int \sqrt{f_0} \, \sqrt{f_0} \log f \, dx\right)^2$$

$$\leq \int f_0 \, dx \int f_0 (\log f)^2 \, dx < \infty. \tag{10}$$

This was implicit when we claimed that the standard deviation of L was $O(\sqrt{N})$.

The condition (7) is weak and is satisfied, for example, if $f \in L^{1.001}(-\infty, \infty)$.

*COROLLARY. Under the conditions of the above theorem, the estimate of f is consistent in the sense that, for each point x_0 , $f(x_0) \rightarrow f_0(x_0)$ in probability.

We are assuming that f and f_0 are continuous, and therefore uniformly continuous in each finite interval. So, given $\epsilon > 0$, there exists δ such that $|f(x) - f(x_0)| < \epsilon$ and $|f_0(x) - f_0(x_0)| < \epsilon$ whenever $|x - x_0| < \delta$. Therefore

$$\left| 2\delta f(x_0) - \int_{x_0 - \delta}^{x_0 + \delta} f(x) \ dx \right| < 2\delta \epsilon,$$

$$\left| 2\delta f_0(x_0) - \int_{x_0 - \delta}^{x_0 + \delta} f_0(x) \ dx \right| < 2\delta \epsilon.$$

Therefore

$$2\delta |f(x_0) - f_0(x_0)|$$

$$< \left| \int_{x_0 - \delta}^{x_0 + \delta} f(x) dx - \int_{x_0 - \delta}^{x_0 + \delta} f_0(x) dx \right| + 4\delta\epsilon.$$

But, by the Theorem,

$$P\left\{ \left| \int_{x_0 - \delta}^{x_0 + \delta} f(x) \, dx \, - \int_{x_0 - \delta}^{x_0 + \delta} f_0(x) \, dx \right| \geq 2\delta\epsilon \right\} \to 0$$
when $N \to \infty$.

Therefore

$$P\{|f(x_0) - f_0(x_0)| \geq 3\epsilon\} \rightarrow 0 \text{ when } N \rightarrow \infty,$$

and this proves the corollary.*

*Conjecture concerning the expected weight of evidence. We shall later be much concerned with the value of W and accordingly the following conjecture is of interest.

Let f be chosen to maximize the functional $\omega(f)$, after a sample of size N has been obtained. Then NE(W), the expectation being taken over all samples from the distribution with density f_0 , seems to tend to a non-zero limit as $N \to \infty$. This conjecture is based partly on numerical evidence to be given later, and partly on the following intuitive argument.

It seems reasonable to assume that

$$f(x) = f_0(x)[1 + h(x)/\sqrt{N}]$$
 (10A)

where h(x) is a random function mathematicaly dependent upon the function f_0 , and having expectation 0 and finite variance for each x. By expanding the logarithm we see that

$$NE(W) = -NE \int f_0(x) \left\{ \frac{h(x)}{\sqrt{N}} - \frac{[h(x)]^2}{2N} + \cdots \right\} dx$$

$$\to \frac{1}{2} \int f_0(x) \text{ var } [h(x)] dx \text{ natural bans.} \quad \stackrel{\mathbb{F}_1^{r}}{\longrightarrow} (10B)$$

Denoting this quantity of evidence by W^* , we may express the conjecture: the expected weight of evi-

dence for discriminating the true density from the fitted one, when the discrimination is based on a sample of the same size as the one giving rise to the fit, tends to W^* when N tends to infinity. This expectation is with respect to variations of both samples.

This conjecture is analogous to the easily provable fact that if a sample of size N is taken from a t-category multinomial distribution, and is used for the consistent and asymptotically efficient estimation of the probability of each category, the expected weight of evidence for discriminating the true set of t probabilities from the estimated ones, based on another sample of size N, tends to (t-1)/2 natural bans as N tends to infinity. Our conjecture can therefore be expressed by saying that a density function $f_0(x)$ behaves in some respects like a multinomial with $t^* = 1 + 2W^*$ categories. We may think of t^* as the equivalent number of multinomial categories, although it need not be an integer. The rougher f_0 is, the larger one would expect t^* to be. Some examples are given in Section 7A.

The above-mentioned proposition for multinomial distributions can be proved as follows. Let the estimator of the probability of the *i*th category be $(1 + h_i)p_i$, so that $E(h_i) = 0$ and $E(h_i^2) = (1 - p_i)/(Np_i)$. Therefore the expected weight of evidence mentioned in the proposition is (in natural bans)

$$NE\left\{\Sigma p_i \log \frac{p_i}{p_i(1+h_i)}\right\}$$

$$= -NE\Sigma p_i h_i + \frac{N}{2} E\Sigma p_i h_i^2 + \cdots$$

$$\rightarrow \frac{1}{2}\Sigma (1-p_i) = (t-1)/2.*$$

4. Comparison With Other Methods

If the statistician makes the assumption that the true density function belongs to a family with a small finite number of parameters, then he can estimate these parameters, for example, by the method of moments, by maximum likelihood, or by a Bayesian method. When the assumption can be safely made it is a pity to waste it. Our procedure, being nonparametric, does not depend on such an assumption. Other nonparametric methods are the 'window methods' (Rosenblatt, 1956; Parzen, 1962), a Bayesian method of Whittle (1958), the use of the Gram-Charlier or Edgeworth series, and a method of Boneva. Kendall & Stefanov (1971), which came to our attention when the present work was almost complete. Although the window methods are consistent they perhaps require large samples, whereas our method makes more use of all the observations at once. Its applicability to small samples might be a valuable feature. It has a Bayesian interpretation, which enables it to come to grips with bumps. It breaks away from the window methods in treating the density function nonlinearly; in this respect it has something in common with the method of Boneva, Kendall and Stefanov. That method also puts a premium on small values of a functional of the density, namely $\int f'^2 dx$ for the one-dimensional case (p = 1). One important distinction is that their purpose is to smooth without much other change to the histogram, so they do not remove its bumps. *In fact their method uses spline interpolation, which preserves the areas of the histogram.* Their results are locally smooth but oscillatory in the large. This is not a criticism of their method as an analyst's aid for the apprehension of the data more or less undoctored. Our method, on the other hand, aims to estimate the true density and to iron out nonsignificant bumps: compare our very smooth Fig. 5 with their bumpy Fig. 2, both of which use the same data. We obtain no negative estimates. Also our method seems to be much more widely applicable than the Gram-Charlier or Edgeworth series. See also the paragraph following equation (16). Whittle's method depends on the assumption of a prior distribution for the density at each point x. This is a much less generalpurpose assumption than ours, and requires more experience in a given problem area to justify it.

*Further history and applications. Most of the credit for pioneering work in nonparametric estimation of a continuous density function, f(x), based on a sample of N observations, x_1, x_2, \dots, x_N , properly belongs to Rosenblatt (1956) although Fix and Hodges (1951) in an earlier paper on nonparametric discriminant analysis considered the estimation of p-dimensional density functions by window methods. Given a sample distribution function $F_N(x)$, the window estimate of the density function is of the form

$$f_N(x) = \int_{-\infty}^{\infty} w_N(x-u) dF_N(u) = \frac{1}{N} \sum_{j=1}^{N} w_N(x-x_j),$$

where

$$\int_{-\infty}^{\infty} w_N(u) \ du = 1.$$

Rosenblatt suggests taking $w_N(u) = (1/N)w(u/h)$, where $h = h_N \to 0$ as $N \to \infty$, and where w(y) is of integrable square. For the special case $w(y) = \frac{1}{2}(|y| < 1)$, 0 otherwise, he shows that the optimal choice for h_N in the asymptotic mean square sense is $h_N = kN^{-1/5}$. He further determines k both for minimizing the mean square or local error $E\{f(x) - f_N(x)\}^2$ and for minimizing the mean integrated square or global error as $N \to \infty$ and $h \to 0$. Unfortunately k is, as he admits, based on an assumed knowledge or guess of the magnitudes of f(x) and f''(x).

Parzen (1962) again used the kernel or window method and proposed the same class of asymptotically unbiased estimators for f(x), and he shows that if $Nh(N) \to \infty$ as $N \to \infty$, then $f_N(x)$ is meansquare consistent and asymptotically normal. He also shows that if f(x) is uniformly continuous, and if $Nh^2 \to \infty$ as $N \to \infty$, then $f_N(x)$ is uniformly consistent in the sense that it tends uniformly in probability to f(x) (i.e. for $\epsilon > 0$, $\Pr[\sup |f_N(x) - f(x)| < \epsilon] \to 1$ as $N \to \infty$). He also gives a general expression for h(N) which minimizes local error but it is rather difficult to compute and has the same objectionable property as the expression for k for the rectangular window of Rosenblatt. He gives a table of seven different choices for w(y), both discrete and continuous.

Many papers have since been written based largely on Rosenblatt and Parzen. Whittle (1958) introduces Bayesian arguments with a view to finding the optimum kernel. Bartlett (1963) considers the problem, as proposed by Rosenblatt, of improving the order $O(N^{4/5})$ of the local error for the one-dimensional case. Watson and Leadbetter (1963) study the class of kernels, $w_N(y)$, proposed by Rosenblatt and derive conditions under which the global error is minimized. Manija (also spelled Maniya) (1961) extends Rosenblatt's work and Nadaraja (also spelled Nadaraya) (1964b) extends Parzen's work to bivariate densities. Nadaraja (1964a) in an earlier paper gives some of Parzen's results without an explicit reference to Parzen. Cacoullos (1964 and 1966) gives a multivariate extension of Parzen's work and gives a stronger result regarding asymptotic normality. Loftsgaarden and Quesenberry (1965) deviate slightly from the Rosenblatt and Parzen multivariate extensions in that instead of counting the number of points lying within a hypersphere, they find the minimum radius of the hypersphere containing a specified number of points. Their method is related to that of Fix and Hodges (1951). Elkins (1968) extends Rosenblatt's rectangular window estimate to p-dimensions as a hypercube or block and compares this method to the hypersphere or ellipsoidal method. He also gives a brief literature review. A more complete one is given by Wegman (1972). Epanechnikov (1969) finds the kernel of minimal global error which turns out to be independent of f(x), N, and the dimensionality p of the space. Nadaraja (1963) proves uniform convergence for the $f_N(x)$ of Parzen and in a subsequent paper (1965) proves that if f(x) is uniformly continuous then for a large class of kernels $f_N(x)$ converges uniformly to f(x). Schuster (1969) gives necessary conditions for uniform convergence of $f_N(x)$. Nadaraja (1965) and Van Ryzin (1969) improve on the weak consistency of Parzen. Murthy (1965a) relaxes the condition of absolute continuity of f(x) and later (1966) extends this to the multivariate case. Craswell (1965) shows that under mild regularity conditions $f_N(x)$ and $f_N(y)$, $x \neq y$, are asymptotically, independently, and normally distributed when suitably normalized. Moore and Henrichon (1969) show uniform consistency for the class of estimators of Loftsgaarden and Quesenberry. Pelto (1969), who investigates adaptive nonparametric classification based on counting points within a hypersphere and simulating a multinormal population, found the efficiency of this method to be no different from that of standard parametric procedures. Specht (1971) uses Tchebycheff-Hermite polynomials in order to increase efficiency in evaluating $f_N(x)$.

In an important paper Čencov (also spelled Chencov) (1962a, b) proposed, independently of Parzen, a different method for estimating f(x) by means of an orthogonal expansion of the form:

$$f_N(x) = \sum_{i=1}^r a_{iN}\theta_i(x),$$

where r is an integer that is not small, and

$$a_{iN} = \frac{1}{N} \sum_{j=1}^{N} \theta_i(x_j),$$

 $\{\theta_i\}$ is an orthogonal set, and f(x) is of integrable square.

In subsequent papers based on Čencov's work Schwartz (1967) investigates the univariate case in which $\{\theta_i\}$ are Hermite functions and Kronmal and Tarter (1968) use Fourier series techniques.

Regarding comparison of the method of kernels to the method of orthogonal functions, Watson (1969) says that there is nothing in theory or practice to recommend one method over the other and Schwartz (1969) says that further work needs to be done.

Van Ryzin (1966) applies Bayesian methods to the work of Parzen (1962), Čencov (1962a), and the related work of Cacoullos (1964) and Aizerman et al (1964).

Applications of density estimation can be found in regression analysis (Nadaraja, 1964c, 1965), hazard analysis (Watson and Leadbetter, 1964a, b), signal detection (Cooper, 1964), nonparametric discrimination (Fix and Hodges, 1951; Stoller, 1954; and Gupta, 1964), reliability (Murthy, 1965b), "bump-hunting" in high-energy experimental physics (Orear and Castle, 1971), and empirical Bayes (Martz and Krutchkoff, 1969). A possible application of bump-hunting in space of high dimensionality would be in a search for clusters ("botryology") in taxonomy or sociology.

Examples of other papers of interest on nonparametric density estimation are Fix and Hodges (1952), Leadbetter and Watson (1962), Leadbetter (1963), Kronmal (1964), Tarter and Kronmal (1967), Blaydon (1967), Weiss and Wolfowitz (1967), Lin (1968), Nadaraja (1966, 1970), Bartlett and Macdonald (1971), Schoenberg (1972), and Hendrickson (1972).*

5. Choice of the Roughness Penalty Φ

One measure of the roughness or complexity of a density function f is the number of bumps in it, which can be defined as one half of the number of points of inflexion (Good, 1950, p. 86). Somewhat in the spirit of the discussion of complexity by Jeffreys (1961, Chapter 3), who regards 2^{-n-1} as the prior probability that a law has n adjustable parameters, the roughness penalty could be taken as proportional to the number of points of inflexion, this being equivalent to assuming that the initial probability of b bumps is of the form e^{-kb} . Compare also the discussion of complexity by Good (1968a). But more information about f is taken into account if the penalty functional of f is assumed to depend on all the values of f' and f'' or on the curvature of the graph of f.

Good (1971a, b) suggested that the roughness might be measured by the ease of discriminating the density curve or hypersurface from itself when it is slid bodily by a slight displacement. Although the suggestion was along Bayesian lines it led, in the onedimensional case, to the proposal that the roughness penalty might be taken proportional to Fisher's information concerning the displacement or location, regarded as a parameter,

$$\int (f'^2/f) dx.$$
 (11)

On putting $f = \gamma^2$, this integral becomes

$$4\int \gamma'^2 dx. \tag{12}$$

Working with γ instead of f replaces the awkward constraint $f \ge 0$ by the convenient one that γ is real. Moreover, (12) is slightly simpler than (11). The constraint $\int f dx = 1$ becomes $\int \gamma^2 dx = 1$ so that $\gamma \in L^2(-\infty, \infty)$, that is, it is of integrable square. Therefore, by the Riesz-Fischer theorem, γ is the limit in mean square of its expansion according to any normal orthogonal system of functions such as the Hermite functions (Riesz, 1907 a, b; Fischer, 1907). The theory of the expansion of functions belonging to L^2 is simpler than that of functions belonging to L. *If we were concerned with functions defined on semi-infinite lines we could use the Laguerre functions, and on finite intervals the Legendre functions. But in this paper we shall be explicit only for the whole of Euclidean spaces, and in particular for the doubly infinite line.*

Apart from the convergence in mean square, questions of ordinary convergence are also of interest and some attention will be paid to them.

When we tried the penalty $4\alpha \int \gamma'^2 dx$, we found it sometimes led to density curves having portions that looked too straight. This was not very surprising because curvature depends also on second derivatives. Since similar methods of analysis were available for $\int \gamma''^2 dx$, we went over to the more general roughness penalty

$$\Phi(f) = 4\alpha \int {\gamma'}^2 dx + \beta \int {\gamma''}^2 dx$$

$$(\alpha \ge 0, \beta \ge 0, \alpha + \beta > 0)$$
 (13)

A referee has commented that if A_1 , A_2 is a dichotomy of $(-\infty, \infty)$,

$$p_i = \int_{A_i} f \, dx$$

and f_i is the density conditional on $x \in A_i$, then

$$\Phi(t) = p_1 \Phi(t_1) + p_2 \Phi(t_2),$$

which is a neat feature.

The results of the numerical work are given in §7, where it is found that smooth density functions were obtained with $\alpha = 0$ and various values of β , even for samples as small as N = 1, 2, or 3. An intuitively reasonable constraint on α and β is given in Appendix D.

Some lower bounds for the penalty, in terms of the

moments of f, are given in Appendix E.

A smooth density function does not remain smooth for all transformations of the x axis, and would be expected to be smooth only if x is chosen as a physically natural variable. This point is discussed in §10.

6. Method of Calculation

We now consider how to maximize the score $\omega(f)$ $=L-\Phi(f)$ when Φ is given by (13). We then write $\omega(f)=\omega(\alpha,\beta;f)=\omega$. The problem of maximizing ω , when α and β and of course x_1, \dots, x_N are given, is a problem in the calculus of variations for which Euler's equations turn out to be inapplicable. We can, however, use the Rayleigh-Ritz method (Courant & Hilbert, 1953, p. 175) with any normal orthogonal system. We select the Hermite system; that is, we use the formal expansion

$$\gamma(x) = \sum_{m=0}^{\infty} \gamma_m \phi_m(x), \qquad (14)$$

where the γ_m are real and

$$\phi_m(x) = e^{-x^2/2} H_m(x) 2^{-m/2} \pi^{-1/4} (m!)^{-1/2}$$
 (15)

$$H_m(x) = (-1)^m e^{x^2} \left(\frac{d}{dx}\right)^m e^{-x^2}.$$
 (16)

Since $\gamma \in L^2(-\infty, \infty)$, (14) is at least true in mean square. It is also true in the sense of Abel summability; see Appendix F. Moreover, if $\gamma \in$ Summability, see Appendix P. Moreover, if $\gamma \in L(-\infty, \infty)$ and is of bounded variation in every finite interval, then the series converges everywhere to $\frac{1}{2}\{\gamma(x+0)+\gamma(x-0)\}$ and therefore to $\gamma(x)$ at all points of continuity of f. This follows from a theorem of Galbrun and Cramér; see, for example, Kendall & Stuart (1969, p. 161). Their notation for H_m differs from ours. These are much less restrictive conditions on γ than the condition for f to have a Gram-Charlier Type A expansion, which is that $\gamma^2 e^{x^2/2} \in L(-\infty, \infty)$.

We shall also want to differentiate (14) term by

term. Owing to the form of $\Phi(f)$, one at least of γ' and γ'' must be of integrable square; we shall assume both of them to be. Then at any rate γ' and γ'' are limits in mean square of their Hermite expansions. Some sufficient condititions for convergence are given in Appendix F.

In numerical work we selected the origin of coordinates at the mean \bar{x} of the sample, and scaled the x-axis to force the usual unbiased estimate of the variance to be equal to $\frac{1}{2}$. A nonlinear transformation with the same result could be used in accordance with §10. This is the most natural choice because when f is a normal distribution of zero mean and variance $\frac{1}{2}$ we have $\gamma = \phi_0$.* (In any applications, after estimating the density function, one should of course hold the standardization in mind.)*

By means of the formalism that underlies the equivalence of Schrödinger's and Heisenberg's formulations of the quantum mechanics of the harmonic oscillator (Appendix A) it can be neatly shown that

$$\int \gamma'^2 dx = \sum_{m=0}^{\infty} (m + \frac{1}{2}) \gamma_m^2$$

$$- \sum_{m=0}^{\infty} \{ (m+1)(m+2) \}^{1/2} \gamma_m \gamma_{m+2}, \qquad (17)$$

$$\int \gamma''^2 dx = \frac{3}{4} \Sigma (2m^2 + 2m + 1) \gamma_m^2$$

$$- \Sigma (2m + 3) \{ (m + 1)(m + 2) \}^{1/2} \gamma_m \gamma_{m+2}$$

$$+ \frac{1}{2} \Sigma \{ (m + 1)(m + 2)(m + 3)(m + 4) \}^{1/2} \gamma_m \gamma_{m+4}.$$
(18)

Further

$$L = \sum_{i=1}^{N} \log \left\{ \sum_{m=0}^{\infty} \gamma_m \phi_m(x_i) \right\}^2$$
 (19)

Hence $\omega(\alpha, \beta; f)$ is maximized by solving the equa-

$$\Sigma \gamma_{m}^{2} = 1, \qquad (20)$$

$$2 \sum_{i=1}^{N} \phi_{k}(x_{i}) \left\{ \sum_{m=0}^{\infty} \gamma_{m} \phi_{m}(x_{i}) \right\}^{-1}$$

$$- 4\alpha [2k\gamma_{k} - \{(k+1)(k+2)\}^{1/2} \gamma_{k+2}$$

$$- \{(k-1)k\}^{1/2} \gamma_{k-2}] - \beta [3k^{2}\gamma_{k} + 3k\gamma_{k}]$$

$$- (2k+3) \{(k+1)(k+2)\}^{1/2} \gamma_{k+2}$$

$$- (2k-1) \{(k-1)k\}^{1/2} \gamma_{k-2}$$

$$+ \frac{1}{2} \{(k+1)(k+2)(k+3)(k+4)\}^{1/2} \gamma_{k+4}$$

$$+ \frac{1}{2} \{(k-3)(k-2)(k-1)k\}^{1/2} \gamma_{k-4} \} - 2\lambda \gamma_{k} = 0$$

$$(k=0,1,\cdots) \qquad (21)$$

for λ , γ_0 , γ_1 , \cdots . For example, when N=1, $x_1=0$, $\alpha=1/4$ and $\beta=0$, and if we disregard γ_k for $k\geq 4$, so that the upper limit of summation becomes 3 instead of infinity, then we find that $\gamma_0 = 1$, so that the 'best' f is normal to this degree of approximation; see Appendix B. This is one of the few cases that can be solved by hand. Its reasonableness encouraged us to write computer programs. All the programming was done by R. A. Gaskins. *A user's program will be submitted for publication elsewhere.*

We used the following method for the computer solution. Take an integer r and assume that $\gamma_r =$ $\gamma_{r+1} = \cdots = 0$. Then proceed iteratively, beginning with $\gamma_0 = 1$. At any stage of the iteration we have current values for $\gamma_0, \gamma_1, \cdots, \gamma_{r-1}$ and λ . We now obtain a new value for $\gamma_k(0 < k < r)$ by substituting the current values of the other unknowns everywhere into (21) except where γ_k occurs linearly. The equation for γ_0 is (20).

An equation for λ is obtainable by multiplying (21) by γ_k and summing. This gives

$$\lambda = N - \Sigma \{4\alpha + \frac{3}{2}\beta(k+1)\}k\gamma_k^2$$

$$+ \Sigma \{4\alpha + \beta(2k+3)\}\{(k+1)(k+2)\}^{1/2}\gamma_k\gamma_{k+2}$$

$$- \frac{1}{2}\beta\Sigma\{(k+1)(k+2)(k+3)(k+4)\}^{1/2}\gamma_k\gamma_{k+4}$$
(22)

$$= N + 2\alpha + \frac{3}{4}\beta - 4\alpha \int \gamma'^2 dx - \beta \int \gamma''^2 dx.$$
(23)

The r + 1 unknowns are computed in turn, cycli-

cally, and the run is stopped when the same value is obtained for λ to five significant figures. We tried r = 20, 50, 100 and 200. In most cases there was no change in the γ_i , to three places of decimals, in going from r = 20 to r = 50. Three samples were tried with r = 50 and r = 100 and the results were identical, with $\gamma_i = 0.000$, for i > 50. We therefore regard the calculations as robust, and we used r = 50in most of the runs. As an example of the values of the coefficients we take those for Fig. 4 with N=20. The γ_{2i-1} all vanish and the γ_{2i} were 0.986, -0.058, -0.124, -0.080, -0.040, 0.022, -0.011, 0.005, -0.002 and all others were less than 0.0005 in absolute value.

This iterative procedure converged in all the examples tried, with a variety of choices for α and β .

*The rougher the underlying population, as measured for example by $\int \gamma''^2 dx$, the larger r needs to be. For example, r = 25 was found not to be large enough for estimating the trimodal density mentioned in Section 7A. If a run is done with a given value of r, and if it is found, after running to convergence,

that any one of γ_{r-1} , γ_{r-2} , or γ_{r-3} exceeds 0.05, then we recommend that r be increased.

The largest value of $\int \gamma''^2 dx$, when the Hermite expansion is truncated after the rth term, $\gamma_{r-1}\phi_r(x)$, is discussed in Appendix EA. For r=25 it is 1629.95 (correct to two places of decimals). If the true value of $\int \gamma''^2 dx$ is larger than this (after standardizing the variance to $\frac{1}{2}$), clearly r = 25would certainly be too small, and could be expected to be too small also when the integral is appreciably smaller. In fact we shall see that it is too small for a certain trimodal density where the integral is equal to about 500.

In the calculations it is much better to use the Hermite functions rather than the Hermite polynomials. The appropriate recursive relation is

$$\phi_m(x) = \sqrt{\frac{2}{m}} x \phi_{m-1}(x) - \sqrt{\frac{m-1}{m}} \phi_{m-2}(x).$$
 (23.1)

Histogram as the raw data. In many high-energy scattering experiments the raw data consists not of Nvalues of x_i but of a histogram in which each interval of values of x corresponds to a single piece of physical equipment and is known as a "bin": see, for example, Orear and Cassell (1971). If the number of events in the jth bin is n_j $(j = 1, 2, \dots, J;$ $\Sigma n_i = N$), then the log-likelihood is

$$\sum_{j=1}^{J} n_{j} \log \int_{B_{j}} f(x) dx$$
 (23.1A)

where B_i is the jth bin. From this we can obtain a score $\omega(f)$ by subtracting the same roughness penalty $\Phi(f)$ that we used before. To maximize $\omega(f)$ we need to solve equations (20) and (21), but with the first term of (21) replaced by

$$2 \sum_{i} n_{i} \left\{ \int_{B_{i}} \Sigma \gamma_{m} \phi_{m}(x) \phi_{k}(x) dx \cdot \left[\int_{B_{i}} (\Sigma \gamma_{m} \phi_{m}(x))^{2} dx \right]^{-1} \right\}$$
 (23.2)

Even λ is given by the same formulae as before. For the calculation of the integrals, over the narrow ranges B_j , we expect it will be sufficient to use the midpoint method with two terms. For the corresponding multidimensional problem the centroid method should work well (Good and Gaskins, 1971a).

The iterative determination of the roughness penalty.

As explained at the end of Appendix D, the fixing of β once and for all is theoretically suspect, and in Section 7A we give some new numerical evidence showing that β definitely cannot be taken as a constant. Accordingly we now describe an iterative method for the selection of a value of β after a sample has been obtained. A more thoroughgoing Bayesian method would require an assumption for a distribution of β , a "Type III distribution" in the terminology of Good (1965, 1967), but we believe that the following compromise with more orthodox statistics would be adequate and easier to apply.

After a sample (x_1, x_2, \dots, x_N) is obtained, and its mean and variance are standardized to 0 and $\frac{1}{2}$, let us smooth it assuming some chosen value of β . This leads to a smoothed density function f_1 which we next regard as a synthetic population density. For this population density we find a near-optimal value of β by methods exemplified in Section 7A where numerical examples are described. This value of β can then be used for the original sample again, thus obtaining a second smoothing f_2 . The process can then be repeated until it converges, the evidence for the convergence of this iterative determination of β , and of the smoothing, being given also in Section 7A.

This procedure will be exemplified elsewhere in relation to some high-energy data supplied by Malcolm H. MacGregor of the Lawrence Radiation Laboratory.

Bump-hunting.

The evidence for or against a bump in a density curve can be evaluated by means of the Bayesian interpretation of the roughness penalty in accordance with formula (4). This can be done once a value for β is accepted.

When applying this method it is necessary to iron out the bump in some way, in order to define a density curve for comparison with the one containing the bump. One way to iron out a bump is to remove some observations in the neighborhood of the bump until it just disappears, that is, the local points of influence disappear. Conversely, if a bump is predicted by some theory, then its presence could be forced by, for example, adding new observations and the evaluation done as before. An example of this procedure will also be reported in connection with MacGregor's data.*

7. Numerical Examples and Graphs

A large number of graphs have been prepared, but to save space many fewer have been given than would really have been desirable. For the reasons given in Appendix D the pairs $(\alpha, \beta) = (\frac{1}{4}, 0)$, $(\frac{1}{8}, \frac{1}{6})$ and $(0, \frac{1}{3})$ were emphasized in the experiments.

In all the graphs the observations have been subjected to a linear transformation to achieve zero mean and unbiased sample variance $\frac{1}{2}$. In Fig. 1, N = 3 and $\beta = 0$ with $\alpha = \frac{1}{4}$, $\frac{1}{2}$, 1 and 2. All four graphs are too bumpy. The bumps could per-

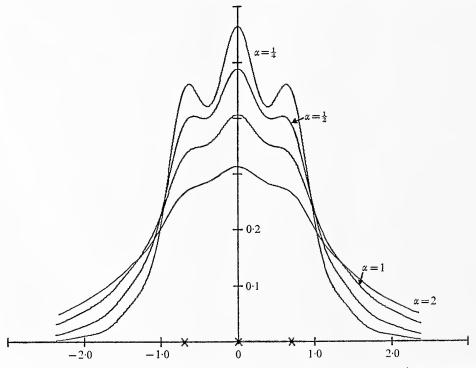


Fig. 1—N=3. $\alpha=\frac{1}{4},\frac{1}{2},1$ and 2; $\beta=0$. Observations $x_1=-1,x_2=0,x_3=1$. \times , Adjusted observations.

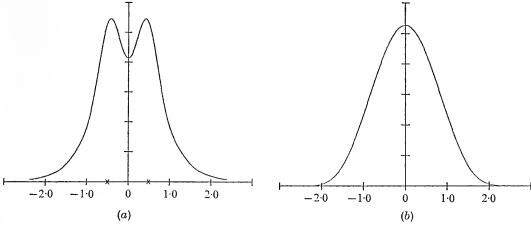
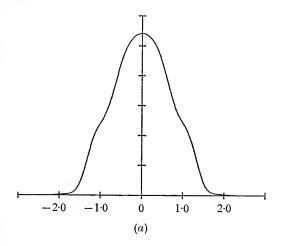


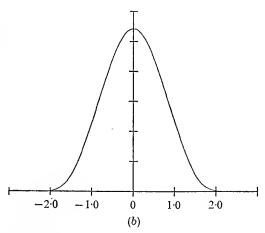
Fig. 2—N = 2. Observations $x_1 = -1$, $x_2 = 1$. In (a) $\alpha = \frac{1}{4}$, $\beta = 0$; (b) $\alpha = 0$, $\beta = \frac{1}{3}$. \times , Adjusted observations.

haps be ironed out by increasing α , but then the variance becomes too large in our opinion, although this objection is not yet decisive.

Figs. 2a, 3a and others not given here show again that $\alpha = \frac{1}{4}$ and $\beta = 0$ is unsatisfactory, although $\frac{1}{4}$ was the value of α preferred a priori after standardization when $\beta = 0$. Apparently smoothness is not captured by the first derivative alone.

Figs. 2–5 show that $\alpha = 0$ and $\beta = \frac{1}{3}$ gives satisfactory smoothings in all examples tried. It is





very much better than (1/4, 0) and appears to be slightly better than (1/8, 1/6). There is little to choose between the pairs (0, 1/3), (0, 1/6) and (0, 2/3) and, on slight evidence, (0, 1/3), except that the former was preferred a priori. A scarcely perceptible bump in one of the graphs not given here, for N=6, was the only graphical evidence against (0, 1/6). If (0, 1/3) is optimal it is to be expected that values of (α, β) that are close to it would be almost as good. The run for $\alpha=0$, $\beta=1/3$ and N=3 took 42 cycles of the iteration to converge whereas $\alpha=0$, $\beta=1/3$ and $\beta=1/3$ and $\beta=1/3$ and $\beta=1/3$.

In case β should be smaller than $\frac{1}{6}$, we tried $\alpha = 0$ and $\beta = \frac{1}{16}$, and we obtained a bimodal curve for $x_1 = -1$ and $x_2 = 1$; a nose cone for $x_1 = -1$, $x_2 = 0$ and $x_3 = 1$; and a distinct bump on the right for the six observations $(-\frac{4}{3}, -1, -\frac{2}{3}, -\frac{1}{4}, \frac{1}{4}, 1)$. We consider these fits counterintuitive.

A few runs were done in error with standardization of the sample variance to 1. It is of interest to note that they gave the same results when correctly

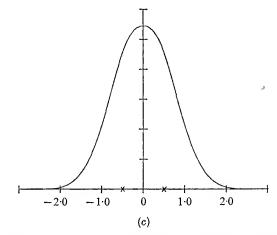


Fig. 3—N=10. Observations at centres of equal probability intervals for standard normal distribution. (a) $\alpha = \frac{1}{4}$, $\beta = 0$; (b) $\alpha = 0$, $\beta = \frac{1}{3}$; (c) $\alpha = 0$, $\beta = \frac{2}{3}$.

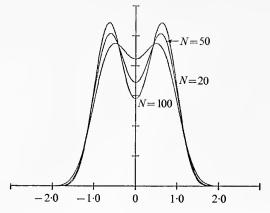


Fig. 4-N = 20, 50 and 100. Observations at the centres of equal probability intervals for the density corresponding to equal mixture of two normal distributions, means $\pm 2/\sqrt{5}$ and variance $\frac{1}{5}$, $\alpha = 0$, $\beta = \frac{1}{3}$. The least bimodal curve is N = 20.

repeated, with the α 's divided by 2 and the β 's by 4. This is another indication of robustness.

In the example of Fig. 3 with N = 10, the graphs with $(\alpha, \beta) = (0, \frac{1}{3}), (0, \frac{1}{8}), (0, \frac{1}{16})$ and $(\frac{1}{8}, \frac{1}{6})$ were barely distinguishable. In the situation of Fig. 4 for a mixture of two normal distributions the true distribution is more bimodal than our fits to it. Naturally the fit is smoother than the true density when the latter is not very smooth.

The data used in Fig. 5 are the same as used by

Boneva et al. (1971) in their Example 1.

We have assumed that when the frequency in one interval was n the observations are at the centres of the *n* equal subintervals into which the interval could be divided. Bliss (1967, p. 97) fitted a normal distribution to the histogram and obtained a χ^2 value of 10.33 with 10 degrees of freedom. Our fit is almost identical with Bliss's but is very slightly skewed to the left.

7A. Simulation Experiments and Deductions.

*Although we obtained smooth results in all the numerical examples when we took $\beta = \frac{1}{3}$, none of these runs made use of random samples from known populations. We have since done some extensive experiments of this kind and they shed much light on the methods. In particular they show that β should not be taken as an absolute constant but rather it depends on the roughness of the underlying population. This *roughness* will now be technically defined as $\int \gamma_0''^2 dx$ where f_0 denotes the underlying density, and γ_0 its square root. We again caution the reader not to confuse γ_0 meaning $\gamma_0(x)$ with γ_0 meaning the coefficient of $\phi_0(x)$ in a Hermite expansion. The corresponding integral for a putative density function will be called a putative roughness. When multiplied by β it becomes the roughness penalty.

The population densities assumed each had variance 1 and were (i) normal (0, 1); (ii) bimodal (Mansfield),

$$\frac{1}{2} \{ \mathfrak{N}(-0.94, \, \sigma^2) + \, \mathfrak{N}(0.94, \, \sigma^2) \},$$

$$\sigma^2 = 1 - 0.94^2 = 0.1164;$$

and (iii) trimodal,

$$\frac{1}{3}$$
{ $\Re(-1.2, 0.04) + \Re(0, 0.04) + \Re(1.2, 0.04)$ }.

These three densities have very different roughnesses, in fact when the variances are standardized to $\frac{1}{2}$ the roughnesses are respectively close to 0.75, 55.4, and 469. The first of these is exact, and the two approximations can be obtained analytically because the normal "components" of the bimodal and trimodal examples are widely enough separated so that the "cleavages" come down almost to the x axis.

For each population we took a (second-order) sample of ν first-order samples, each of size N, where ν was at least 100 in each case. N was 50 for the normal population, 100 and 200 (in two experiments) for the bimodal population and was 150 for the trimodal population. The smoothings were done with a variety of values of β and with r = 25terms of the Hermite expansions. But we found that 25 terms were not enough for the trimodal data, in that, for example, the coefficient γ_{24} was large (greater than 0.1) for all ν first-order samples. It was clear that the runs for the trimodal density were trying to break through to the higher dimensions of Hilbert space, so we increased r to 50 and found that the later coefficients were very small (such as 0.003). Accordingly for the trimodal population we shall report only the experiments where r was 50.

Three criteria were used for measuring how good a fit a putative density f was to the population

density f_0 . These were: (i) The closeness of the putative roughness $\int f''^2 dx$ to the true roughness $\int f_0''^2 dx$.

(ii) The expected weight of evidence W per observation for distinguishing the putative population from the true one, where W is the positive quantity

$$W = \int f_0(x) \log \frac{f_0(x)}{f(x)} dx.$$
 (23.3)

The expression "weight of evidence" is here used in the sense of Peirce (1878) or Good (1950), and the integral W has a long history dating back at least

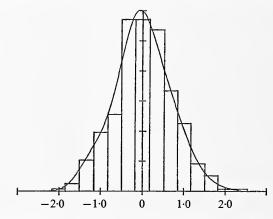


Fig. 5—N = 578. $\alpha = 0$, $\beta = \frac{1}{3}$. Lengths of ears of corn, derived from the histogram of Bliss (1967), who was quoting Emerson and East.

to Willard Gibbs, but we shall not list the numerous references here. For each sample of the first order, W can be calculated by numerical integration, the centroid method being convenient in the multidimensional case (Good and Gaskins, 1971a), and the mean value and standard deviations of W can be estimated from the sample of the second order. We also printed, at negligible cost,

$$\int f(x) \log \frac{f(x)}{f_0(x)} dx,$$

which, in accordance with a theorem of Turing's is approximately equal to W (Good, 1950, p. 73); and the mean squared errors

$$\int [f(x) - f_0(x)]^2 f_0(x) \ dx \text{ and } \int [f(x) - f_0(x)]^2 f(x) \ dx;$$

(23.4)

but for the sake of simplicity we used only W. Note that W is invariant under a non-singular transformation of x, as is, more generally,

$$\int F(f(x), f_0(x)) dx \qquad (23.5)$$

where F is any homogeneous function of degree 1 such as $[f(x) - f_0(x)]^2/f(x)$. The mean squared errors are variant.

(iii) The closeness of the maximum height of

the putative density curve to the true one.

All three of these criteria are exogenous in the sense that they require knowledge of the true density. We shall see, however, that they lead to a reasonable justification of the iterative determination of β for practical applications (see Section 6) where the true population is of course unknown.

Results of the new computer simulation runs. We use the following abbreviations in the tabulations: Max. Ht. = Maximum height of a density curve; P. R. = putative roughness = R. P./ β where R. P. = roughness penalty; mb = millibans. The estimate of W is denoted by \overline{W} . The estimated means are shown with the usual estimates of the standard errors of

these estimates in parentheses. The variability of the standard errors is partly due to variations in the number ν of first-order samples used. For the Max. Hts., ν was only 5, but the standard errors were small. The results for the normal, biomdal and trimodal populations are shown in Tables 0.1, 0.2, and 0.3. The runs were done with various values for N, and ν , the sizes of the first-order and second-order samples. It is more informative to increase N by a given factor than to increase ν by the same factor, but the running time is proportional to ν and more than proportional to N, perhaps proportional to N log N.

When N is too small to lead to a very accurate estimate of the population density, the estimated density curve is likely to have lower roughness than the population. Thus, for a given value of β , the expected roughness penalties increase with N. They should tend to a limit as $N \to \infty$, namely β times the roughness of the population. If N is small and if we infer the approximate value of β by equating the putative to the population roughness we shall tend to underestimate β . The rougher the population, the larger N will need to be, to estimate β to a specified accuracy. But diminishing returns presumably set in fairly quickly, for this purpose, because a difference of a factor of 2 in β makes little difference to the estimated density curve, in our experience.

For all three populations, the rows of the tables have very smooth graphs which, however, have not been included in this paper. The extreme smoothness of these rows arises because the various values of β were applied to the same samples from the populations. The samples for different N's are different. Of the three "exogenous" criteria the one that fixes β most precisely is the equating of the putative roughness to the population roughness; for it is easier to estimate the point where a monotonic curve cuts a horizontal one than where a curve takes a stationary value, when both curves have comparable sampling errors. Moreover the standard errors of the putative roughnesses are small.

From the various graphs we obtained point esti-

TABLE 0.1

Results of simulation runs for the normal population with roughness = 0.75 and Max. Ht. = 0.398. The standard errors of Max. Ht. are all about 0.03 or 0.04 in (a) and (b)

				(a) $N = 50$	$0, \nu = 100.$				
β	1/24	1/12	1/6	1/3	2/3	4/3	8/3	16/3	32/3
R.P. P.R. W(mb) Max Ht.	0.49(.03) 11.7(.7) 45(2.1)	0.63(.01) 7.5(.12) 37(2.3)		0.84(.03) 2.52(.09) 26.4(1.4)	1.02(.3) 1.52(.04) 18.9(1.4) 0.426	1.34(.03) 1.01(.02) 14.6(1.1) 0.413	1.93(.02) 0.72(.01) 11.9(.9) 0.396	2.84(.02) 0.53(.003) 12.1(.8) 0.373	4.07(.01) 0.381(.001) 17.3(1.0) 0.346
				(b) $N = 2$	$25, \nu = 16.$				
β	1/24	1/12	1/6	1/3	2/3	4/3	8/3	16/3	32/3
R.P. P.R. W(mb) Max Ht.	0.54(.07) 12.9(1.8) 99(23) 0.525	0.60(.07) 7.2(.9) 87(23) 0.506	0.65(.07) 3.9(.4) 74(21) 0.487	0.73(.07) 2.2(.2) 60(19) 0.469	0.88(.07) 1.3(.1) 48(16) 0.449	1.15(.06) 0.9(.04) 38(12) 0.425	1.58(.04) 0.59(.017) 32(9) 0.397	2.16(.03) 0.40(.005) 31(7) 0.366	2.83(.02) 0.27(.001) 39(6) 0.332

Results of runs for the bimodal population with roughness = 55.4, and Max. Ht. = 0.575. The standard errors of the Max. Hts. in (a) are all about 0.006. The Max. Hts. were not observed in (b)

		(a) $N =$	$200, \nu = 100.$			
β	1/24	1/12	1/6	1/3	2/3	
R.P. P.R W(mb) Max Ht	2.77(.04) 66.6(1.0) 6.6(.36) 0.615	5.05(.07) 60.6(.8) 6.4(.33) 0.602	8.51(.12) 51.0(.7) 7.5(.32) 0.580	12.7(.17) 38.2(.5) 12.4(.4) 0.544	16.3(.19) 24.5(.3) 24.9(.4) 0.493	
		(b) N =	100, $\nu = 100$.			
β	1/24	1/12	1/6	1/3	2/3	
R.P. P.R. <i>W</i> (mb)	2.75(.06) 66.0(1.4) 12.5(.6)	4.55(.09) 54.6(1.1) 12.4(.5)	6.69(.12) 40.1(.7) 16.2(.5)	8.47(.14) 25.4(.4) 28.1(.6)	9.20(.13) 13.8(.2) 49(.6)	

mates of β for the three populations, using each of the three exogenous criteria, and for two pairs (N, ν) for each population. These point estimates are shown in Table 0.4. For each population, the estimates have an adequate degree of coherence and we believe that the best of the estimates are given by the putative roughness criterion and the larger sample sizes. This belief leads us to the estimates 2.45, 0.125, and 0.0147 for β corresponding to the normal, bimodal, and trimodal populations. If these are plotted against the population roughnesses on double-logarithmic paper we obtain approximately a straight line fit. This leads to the approximate empirical formula, a regression of β given the population roughness,

$$\beta \approx 2.15 \times (\text{Population roughness})^{-0.78}$$
. (23.6)

Perhaps the left side should be written $\hat{\beta}$. We think this will give a useful first approximation to β when the population roughness can be reasonably guessed. It can certainly be reasonably guessed for the bumphunting data provided by Malcolm MacGregor.

On the other hand, when β is varied for a given sample (x_1, x_2, \dots, x_N) , the putative roughness

TABLE 0.3

Results of runs for the trimodal population with roughness = 469 and Max. Ht. = 0.665. In (a), the S. E.'s of Max Ht. are all about 0.025 and in (b) are 0.04.

	(a)	$N=150, \nu$	= 100.	
β	1/192	1/96	1/48	1/24
R.P. P.R.	2.94(.058) 564(11) 12.9(.7) 0.733	5.31(.11) 509(10) 12.3(.6) 0.713	8.75(.16) 420(8) 13.6(.6) 0.678	12.5(.21) 300(5) 21(.7) 0.597
	(b)	$N = 50, \nu$	= 50.	
β	1/384	1/192	1/96	1/48
R.P. P.R.	1.61(.06) 619(25)	2.72(.1) 522(19)	3.99(.13) 383(12)	4.99(.14) 240(7)

31.9(3)

0.836

32.9(3)

0.786

34.7(3)

0.864

can be regressed on β , and typical results can be read off from Tables 0.1, 0.2, and 0.3. We find that a graph consisting of points with (abscissa = estimate of log β , ordinate = logarithm of population roughness) descends faster than the graphs of points with (abscissa = log β , ordinate = putative roughness). Whenever this is the case the iterative determination of the roughness penalty, described near the end of Section 6, should converge up or down a "staircase," as the reader may verify by drawing a diagram.

We remind the reader of the interpretation of W by means of an example. Take the bimodal population with N=200, where the minimum of the expectation of W is about 6.4 millibans. A typical sample used with N=200 would give an estimated density curve that could be discriminated from the true density at a rate of 6.4 millibans per *later* observation. For example, 100 later observations would give an expected weight of evidence of 6.4 decibans, a Bayes factor of about 4. The standard deviation of this score of 6.4 db is large, being about $3\sqrt{6.4}=6.7$ db if the distribution of the score is normal.

The conjectures made near formula (10B) are roughly borne out by Tables 0.1, 0.2, and 0.3. The values of W^* , as estimated from these tables, are 1.4 or 1.8 for the normal population, 2.9 or 2.9 for the bimodal, and 4.2 or 3.7 for the trimodal population. The first of each of these pairs are the more reliable, being based on larger values of N. It is not surprising that they are closely proportional to the numbers of modes when one considers the shapes of the density curves. The "equivalent numbers of multinomial categories" t^* (see Section 3) are about 4, 7 and 9.*

8. Comparison of Fits

It is useful and essential for bump theory to be able to compare different assumptions for f more objectively than by visual inspection alone, when the observations x_1, \dots, x_N are given.

When two assumptions both use the same penalty functional the comparison can be made under the Bayesian interpretation. Of course, in this case one

43.1(2.3)

0.711

 $\tilde{W}(mb)$

Max Ht.

TABLE 0.4 Point estimates of β for the three populations

		ν	From P.R.	From Max. Ht.	From \overline{W}	Roughness	
Normal	50 25	100 16	2.45 1.73	2.45 2.91	3.36 4.23	0.75	•
Bimodal	200 100	100 100	0.125 0.074	0.19	0.094 0.059	55.4	
Trimodal	150 50	100 50	0.0147 0.0069	0.025 0.025	0.010 0.006	469	

of the f's will not be the optimal one. We give the

simple theory that is required for the comparison. Let $f_1 = \gamma_1^2$ and $f_2 = \gamma_2^2$ be regarded as defining two hypotheses H_1 and H_2 , and let E denote the observations. Let the values of L under H_1 and H_2 be L_1 and L_2 , respectively. Let $O(H_1|H_2 \mid \hat{E}, \alpha_1, \beta_1)$ denote the final odds of H_1 as compared with H_2 given E and assuming $\alpha = \alpha_1$, and $\beta = \beta_1$. * $(\gamma_1 \text{ and } \beta)$ γ_2 should not be confused with the coefficients in (14).)* Then, by (4),

$$\log O(H_1/H_2 \mid E, \alpha_1, \beta_1) = \omega(\alpha_1, \beta_1; f_1) - \left(\log L_2 - 4\alpha_1 \int {\gamma_2}'^2 dx - \beta_1 \int {\gamma_2}''^2 dx\right) \cdot (24)$$

Of course, this is positive because f_1 maximizes $\omega(\alpha_1,$ β_1 ; j). To exemplify this formula we were opportunistic and made use of some of the machine output (Table 1). For brevity we consider only the case

TABLE 1 Some machine output

α	β	I	$\log L$ in cb	Penalty	Score	$\int \gamma'^2 dx$	$\int \gamma''^2 dx$
1	0	18	-264	61	-325	0.352	1 · 213
$\frac{1}{2}$	0	20	-241	46	-287	0.538	3 · 570
1/4	0	12	-223	35	-259	0.822	10 · 449
18	16	10	-240	23	-264	0.607	1 · 429
0	1 6	11	-236	13	-250	0.701	1.830
0	1/3	14	-244	16	-260	0.598	$1 \cdot 106$
0	2 3	21	-252	20	-272	0.505	0.712
	$ \begin{array}{c} 1 \\ \frac{1}{2} \\ \frac{1}{4} \\ \frac{1}{8} \\ 0 \\ 0 \end{array} $	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	α β I in cb Penalty Score $\int \gamma'^2 dx$ 1 0 18 -264 61 -325 0.352 $\frac{1}{2}$ 0 20 -241 46 -287 0.538 $\frac{1}{4}$ 0 12 -223 35 -259 0.822 $\frac{1}{8}$ $\frac{1}{6}$ 10 -240 23 -264 0.607 0 $\frac{1}{6}$ 11 -236 13 -250 0.701 0 $\frac{1}{3}$ 14 -244 16 -260 0.598

The column I gives the number of cycles in the iteration before convergence. The log likelihood, penalty, and score, are in centibans (cb), so that the score is $43 \cdot 43\omega(\alpha, \beta; f)$.

N = 6, and the comparisons are shown in Table 2.

The above argument is not rigorous because the density functions $\exp(-\Phi)$ are improper, in the novel sense that their normalizing constants are infinite, not zero. Intuitively this is because almost all density functions are very rough and have

$$\exp\left(-\int \gamma'^2 dx\right) = \exp\left(-\int \gamma''^2 dx\right) = 0.$$

The integrals of $\exp(-\int \gamma''^2 dx)$ over the spheres $\gamma_0^2 + \gamma_1^2 + \cdots + \gamma_{m-1}^2 = 1$, for m = 4, 8, 12 and 16, were computed by making use of formulae in a 1963 report, now published in Good (1971c). These integrals were found to be 0.625, 0.0150, 5.64 \times 10⁻⁵ and 6.27 \times 10⁻⁸, respectively, fairly obviously tending to zero as $m \to \infty$. *(We have made a correction here to the Biometrika ver-

The argument can be made more rigorous by imagining the Hermite expansions to be carried out to only a trillion terms which makes the normalizing constants finite. An estimation method with a trillion parameters is nonparametric! Another way to force propriety would be to divide the roughness penalties by $\int \gamma^2 dx + 0.01 \int \gamma''^2 dx$, although this is ad hoc. The normalizing constants of the prior distribution could then be deduced in principle from the theory of the average of the exponential of a homogeneous function on a hypersphere, given in the same report. This is why we wrote 1 as $\int \gamma^2 dx$.

The need for natural finite normalizing constants is more serious when we wish to compare two different pairs (α_1, β_1) and (α_2, β_2) . It would be convenient to have a ('Type III') initial distribution of (α, β) , eombined with propriety of the (Type II) priors in function space. Failing this, we can only fall back on a strong intuitive feeling that if f_1 beats f_2 easily, assuming (α_1, β_1) , but f_2 does not beat f_1 easily, assuming (α_2, β_2) , then we have obtained useful evidence in favour of f_1 . For example, in Table 2, (0, 3/3) on its own ground beats $(\frac{1}{4}, 0)$ by 254 cb, a factor of over 300, but loses only 15 cb on its opponent's ground. The pairs $(\frac{1}{8}, \frac{1}{6})$, $(0, \frac{1}{6})$, $(0, \frac{1}{3})$, $(0, \frac{2}{3})$ and $(0, \frac{4}{3})$ never had as much as 3 cb scored against them in

TABLE 2.

Final log-odds in centibans for discriminating between pairs of assumed density functions, N = 6

Hypotheses	(1, 0)	$(\frac{1}{2}, 0)$	$(\frac{1}{4}, 0)$	$\left(\frac{1}{8},\frac{1}{6}\right)$	$(0, \frac{1}{6})$	$(0, \frac{1}{3})$	$(0, \frac{2}{3})$
(1, 0)	0	10	41	19	33	23	15
$(\frac{1}{2}, 0)$	8	0	7	6	10	9	9
$(\frac{1}{4}, 0)$	20	5	0	7	7	11	15
$(\frac{1}{8}, \frac{1}{6})$	17	15	53	0	0	1	4
$(0, \frac{1}{6})$	23	17	49	0	0	2	7
$(0, \frac{1}{3})$	22	32	114	1	3	0	2
$(0, \frac{2}{3})$	27	71	254	9	17	4	0

The hypotheses are defined by the 'best' density functions corresponding to the values of (α, β) shown. The entry in a row labelled (α_1, β_1) and column labelled (α_2, β_2) is the log-odds in centibans in favour of the best density function corresponding to (α_1, β_1) as against the best density function corresponding to (α_2, β_2) , when the coefficients in the penalty are assumed to be $(\alpha_1, \beta_1).$

calculations more extensive than those shown in Table 2, but (${}^{1}4$, 0) was over 8 bans down in its 'away encounter' with $(0, {}^{4}3)$ for N=3, corresponding to log odds of 100,000,000 to 1 against. This method for comparing priors is controversial but we believe in it. Philosophically it is similar to the use of Type II maximum likelihood as described by Good (1967). *The method is, however, only approximate and there is some numerical evidence that larger values of β have an unfair advantage and should be substantially handicapped. Until this point has been further investigated, this method of comparing pairs of values of β should be used with caution.*

9. Extension to Multivariate Densities

Let \mathbf{x} be a random vector with components (x_1, \dots, x_p) . This notation should not lead to confusion because vector observations would be denoted by $\mathbf{x}_1, \dots, \mathbf{x}_N$. The use of superscripts to denote components, as in some treatises on tensors, has other disadvantages, and the usual justification for it is untenable as pointed out by Schrödinger (1950, p. 7).

If f is a multivariate density of x we again write $\gamma = \sqrt{f}$. We note for future reference that Fisher's information matrix, regarding the location of the density hypersurface, when it is slid bodily, can be

written in the form, generalizing (12),

$$\mathbf{F} = \left\{ 4 \int \frac{\partial \gamma}{\partial x_i} \frac{\partial \gamma}{\partial x_j} d\mathbf{x} \right\} \qquad (i, j = 1, \dots, p). \quad (25)$$

We should like to find appropriate and natural generalizations of the one-dimensional functionals $\int \gamma'^2 dx$ and $\int \gamma''^2 dx$. A desideratum is 'additivity' in a sense now to be explained for the case p=2. Let the roughness penalty for a p-dimensional limits to f.

Let the roughness penalty for a p-dimensional density $f = \gamma^2$ be denoted by $\Phi_p(f)$ when p > 1. Assume that Φ_2 is the integral over the plane $-\infty < x < \infty, -\infty < y < \infty$, of some expression involving γ and its partial derivatives. Now when $\gamma(x, y)$ is of the form $\gamma_1(x)$ $\gamma_2(y)$, that is, if x and y are assumed to be statistically independent, Φ_2 should be the sum of the separate penalties for $\gamma_1(x)$ and $\gamma_2(y)$. Expressed in terms of Alonzo Church's λ -calculus, we should have

$$\Phi_2\{(\lambda x, \lambda y)\gamma_1(x)\gamma_2(y)\} = \Phi(\gamma_1) + \Phi(\gamma_2), \qquad (26)$$

a condition we describe as additivity. The λ in §6 is different! The generalization of this definition to p dimensions does not need to be spelt out. The condition of additivity is required for logical consistency; otherwise the 'best' density function, assuming independence, would not be the same as that obtained by treating x and y separately. The need for this desideratum depends of course on the additivity of the log likelihoods from which the penalties are to be subtracted.

From now on we shall assume the existence and continuity of all derivatives that occur, and also that the densities and all their mentioned derivatives

tend to zero at infinity.

For any positive integer r, consider the following functional of $\gamma(x, y) = \gamma_1(x)\gamma_2(y)$:

$$\iint \left\{ \left(\frac{\partial^r \gamma}{\partial x^r} \right)^2 + \left(\frac{\partial^r \gamma}{\partial y^r} \right)^2 \right\} dx dy$$

$$= \iint \left[\left\{ \gamma_1^{(r)} \right\}^2 \gamma_2^2 + \gamma_1^2 \left\{ \gamma_2^{(r)} \right\}^2 \right] dx dy$$

$$= \iint \left\{ \gamma_1^{(r)} \right\}^2 dx + \int \left\{ \gamma_2^{(r)} \right\}^2 dy.$$

Thus the penalty (13) can be additively generalized in a straightforward way to

$$\Phi_{p}(f) = 4\alpha \int (\nabla \gamma)^{2} d\mathbf{x} + \beta \int \sum_{i=1}^{p} \left(\frac{\partial^{2} \gamma}{\partial x_{i}^{2}}\right)^{2} d\mathbf{x}, \quad (27)$$

where $d\mathbf{x}$ means $dx_1 \cdots dx_p$ as usual, and the bold integral sign denotes a multiple integral. The first term is α tr (F). By means of some partial integrations we can write Φ_p as

$$\Phi_{p}(f) = -4\alpha \int \gamma \nabla^{2} \gamma \ d\mathbf{x} + \beta \int \gamma \sum_{i=1}^{p} \frac{\partial^{4} \gamma}{\partial x_{i}^{4}} \ d\mathbf{x} \quad (28)$$

$$= -4\alpha E(\gamma^{-1}\nabla^2\gamma) + \beta E\left(\gamma^{-1}\sum_i \frac{\partial^4\gamma}{\partial x_i^4}\right).$$
 (29)

The first term can also be written as

$$+ 4\alpha E(\gamma^{-2}(\nabla \gamma)^2). \tag{30}$$

An example of a penalty that is not additive is $E(\nabla^2 \gamma)^2$. When the above penalty is used, we would select the origin at the mean \bar{x} of the observations and we might apply a linear transformation so as to force the sample covariance matrix to be $(\frac{1}{2}\delta_i)$. Then Hermite functions in several variables could be used but with $H_m(\mathbf{x})$ equal simply to $H_{m_1}(x_1) \cdots H_{m_p}(x_p)$. Alternatively, we could use the generalized Hermite functions defined in Appendix A, with the matrix C equal to the usual unbiased estimate of the covariance matrix; remember the notational inconsistency between the univariate and multivariate Hermite functions. The numerical devices of §6 can all be extended to the multivariate problem; see especially Appendix A. The calculations are clearly simplest when C is a scalar multiple of the identity, and this case might often be adequate in view of the robustness noted at the end of §7.

An objection that can be brought against the penalty (28), is that the various co-ordinates x_1, \dots, x_p should not necessarily be given equal weight, whether they are left untransformed or are transformed as above. For example, if the scales of some of the co-ordinates are changed, the use of the penalty (28) would produce a different 'best' density function after transforming back to the original co-ordinates. Some condition of invariance is therefore desirable and is discussed in §10.

If a density $f_i(\mathbf{x})$ has some continuous components and some discrete ones $\mathbf{i} = (i_1, i_2, \cdots)$, such as will occur in medical diagnostic problems (see Dickey,

1968, who used a kind of window method), we could try a roughness penalty consisting of a linear combination of the entropy (see §2) and of the Φ 's corresponding to each value of i. This raises computational problems not yet examined.

It is interesting to ask how bumps should be counted in more than one dimension. In one dimension, as mentioned in Section 5, the number of bumps could be defined as one half of the number of points of inflexion. Perhaps a good definition in two dimensions would be the number of "closed" curves (where "closed" includes curves that run to infinity), along which the Gaussian curvature vanishes; and in p dimensions perhaps it should be the number of (p-1)-dimensional simply-connected "closed" hypersurfaces at each point of which the Gaussian curvature vanishes.

10. Invariance

Even in one dimension (p = 1), a transformation of co-ordinates raises problems. A density function cannot remain smooth under all transformations, even when they are nonsingular and differentiable as many times as one requires, a condition that we assume throughout. Belief in smoothness is rational only if the random variable x is reasonably natural from a physical or from some other point of view. The question arises whether a 'best' invariant density can be defined under all well-behaved transformations of x or x. Whittle (1958) pointed out that his method had this invariance property. An invariant method can be achieved in terms of the tensor calculus if a natural fundamental tensor can be introduced into x space. This can be done, except when ignorance is bliss, see below, in terms of the 'biutility' v(x, y), defined as the utility of assuming that a random variable has the value y when the true value is x (Good, 1968b, 1969, 1971a, b). It seems to be the most natural method that does not go outside the probability and utility structure of a given density-estimation problem.

As explained in Appendix C, when ignorance is not bliss, we can define a fundamental tensor and its matrix by

$$g_{ij} = \left[-\frac{\partial^2 v(\mathbf{x}, \mathbf{y})}{\partial y_i \partial y_j} \right]_{\mathbf{y} = \mathbf{x}}, \qquad \mathbf{G} = \{g_{ij}\}. \tag{31}$$

The matrix G is positive semidefinite if $v(x, x) \ge$ v(x, y), and we shall assume it to be positive definite, a fairly small assumption. In particular v(x, x) – v(x, y) must not be only a fourth-order infinitesimal when y is close to x. If f is any probability density function, g_{ij} is a covariant tensor of the second order and $fg^{-1/2}$ is invariant, where $g = \det(G)$. In the standard terminology of the tensor calculus, f is a scalar density (for example, Eddington (1924, p. 111); or Weatherburn (1938, p. 33)). Hence ζ , defined as

 $\gamma g^{-1/4}$, is a relative scalar of weight $\frac{1}{2}$. We can now redefine the penalty (28) in an invariant form. The logic is slightly easier in terms of expectations than in terms of integrals because the expected value of an invariant, unlike its integral, is again an invariant. In these expectations we first

replace γ by ζ . Now the expressions $(\nabla \zeta)^2$ and $\nabla^2 \zeta$ have well-known tensorial expressions (for example, Weatherburn (1938, pp. 43, 67)), namely $g^{ii}\zeta_{,i}\zeta_{,j}$ and $g^{ii}\zeta_{,ij}$, where the commas imply covariant differentiation with respect to all the suffixes following them, and where of course we are using the summation convention. The first covariant derivative of an invariant is equal to its ordinary derivative, but the second one involves a Christoffel three-index symbol. Hence the generalization of the first term of $\Phi_p(f)$ is 4α times

$$E(\zeta^{-2}g^{ii}\zeta_{,i}\zeta_{,i})$$

$$= \int \gamma^{2}\zeta^{-2}g^{ii}\zeta_{,i}\zeta_{,i} d\mathbf{x} = \int \zeta_{,i}\zeta_{,i}g^{ii}\sqrt{g} d\mathbf{x} \qquad (32)$$

$$= -E(\zeta^{-1}g^{ii}\zeta_{,ii}) = -\int \gamma^{2}\zeta^{-1}g^{ii}\zeta_{,ii} d\mathbf{x}$$

$$= -\int \zeta\zeta_{,ii}g^{ii}\sqrt{g} d\mathbf{x}. \qquad (33)$$

The equality of the expressions on the right of (32) and (33) can be verified by what may be called covariant partial integration, the justification of which is Ricci's lemma that g_{ij} , g^{ij} and g behave like constants in covariant differentiation. For the same reason we have

$$\zeta_{,i} = g^{-1/4} \gamma_{:i}, \qquad \zeta_{,ij} = g^{-1/4} \gamma_{:ij}, \qquad (34)$$

where the covariant differentiation of relative scalars and tensors is defined, for example, by Korn & Korn (1961, p. 490). A colon is used here to denote this form of covariant differentiation to distinguish it from the more familiar covariant differentiation of absolute scalars and tensors. The reader might prefer the formulae expressed in terms of ζ instead of γ . *(A relative tensor of weight K is such that when multiplied by $g^{-K/2}$ it becomes an absolute tensor. The covariant derivative of such a relative tensor is $g^{K/2}$ times the covariant derivative of the corresponding absolute tensor.)*

The invariant form of the first term of $\Phi_p(f)$ can be written as

$$4\alpha \int \gamma_{:i} \gamma_{:i} g^{ij} d\mathbf{x} = -4\alpha \int \gamma \gamma_{:ij} g^{ij} d\mathbf{x}.$$
 (35)

Similarly, the invariant generalization of Fisher's information matrix with respect to location of the slid density hypersurface is

$$\mathbf{F} = \left\{ 4E(\zeta^{-2}\zeta_{,i}\zeta_{,i}) \right\}$$

$$= \left\{ 4 \int \zeta_{,i}\zeta_{,i}g^{1/2} d\mathbf{x} \right\} = \left\{ 4 \int \gamma_{,i}\gamma_{,i} d\mathbf{x} \right\}. \tag{36}$$

The previous formula (25) is recovered when G is the identity matrix; in fact this is always the condition under which the tensorial expressions specialize to those in §8. Compare the invariant form of entropy in Good (1968b, 1969). The first term of $\Phi_p(f)$ can be expressed as α tr (FG), when G is a constant matrix.

To generalize the second term of Φ_p we note that

the fourth covariant derivative $\zeta_{,ijkl}$ is symmetric in its first two suffixes so that a natural invariant is

$$\theta^* = \frac{2}{3} \zeta_{,ijkl} g^{ik} g^{il} + \frac{1}{3} \zeta_{,ijkl} g^{ij} g^{kl}. \tag{37}$$

Hence an invariant form for the second term Φ_p is β times

$$E(\zeta^{-1}\theta^*) = \int \gamma^2 \zeta^{-1}\theta^* dx$$
$$= \int \zeta \theta^* g^{1/2} dx \qquad (38)$$

$$= \int \gamma \theta \ dx, \tag{39}$$

where

$$\theta = \frac{2}{3}\gamma_{:ijkl}g^{ik}g^{jl} + \frac{1}{3}\gamma_{:ijkl}g^{ij}g^{kl}.$$
 (40)

Thus, an invariant form for $\Phi_p(f)$ is

$$\Phi_p(f) = 4\alpha \int \gamma_{:i} \gamma_{:j} g^{ij} dx + \beta \int \gamma \theta dx \qquad (41)$$

$$= -4\alpha \int \gamma \gamma_{:ij} g^{ij} dx + \beta \int \gamma \theta dx.$$
 (42)

Note that the penalty vanishes if f is proportional to $g^{1/2}$, so this is the best density when there are no observations, although it might be an improper density. It is not a prior in the usual sense because the distribution of x that we are estimating is assumed to have a physical rather than only a logical or subjective existence; contrast Jeffreys (1946).

Special cases. If v(x, y) is of the form $u\{(x - y)^2\}$ with $u'(0) = -\frac{1}{2}$, then G is the identity and the tensorial expressions of §9 reduce to those of §8. Again, if v(x, y) is any well-behaved function of a quadratic form in x - y, such as the often reasonable form

$$1 - \exp \{-(x - y)'A(x - y)\},$$

with A positive definite, then the fundamental tensor g_{ij} becomes constant. Since it is positive definite, a transformation of co-ordinates can be made so as to reduce the first fundamental form to $dx_1^2 + \cdots + dx_p^2$, that is, the x space is Euclidean, g = 1 and $\zeta = \gamma$, and (42) reduces to (28). More generally, the x space can be made Euclidean, or in tensor terminology it already is Euclidean, if the Riemann-Christoffel curvature tensor vanishes (Eddington, 1924, p. 80; Weatherburn, 1938, p. 117).

In one dimension (p = 1), the Riemann-Christoffel

In one dimension (p = 1), the Riemann-Christoffel tensor always vanishes; a one-dimensional manifold has no intrinsic curvature. Note that this is not to say that the density function has no curvature when regarded as embedded in the two-dimensional space in which x is only one of the co-ordinates. A transformation that converts the metric $ds^2 = g_{11} dx^2$ into $d\xi^2$ is clearly

$$\xi = \int_0^x \left\{ \left[-\frac{\partial^2 v(z, y)}{\partial y^2} \right]_{y=z} \right\}^{1/2} dz. \tag{43}$$

11. Contrast with Quantum Mechanics

Since we have used some mathematical techniques that occur in quantum mechanics, it might be thought that our methods could be applied to the smoothing of probability densities of measurements in quantummechanical experiments with unknown wave functions but whose states have been prepared in the sense defined, for example, by Ballentine (1970, p. 366). But these densities are usually flamboyant because they arise as the squares of absolute values of complex wave functions, whereas our functions $\gamma(x)$ are real. Our methods could, without modification, be applied to such problems but the samples would have to be large enough to pick up the oscillations. Alternatively y could be replaced by the unknown complex wave function ψ , where $|\psi|^2 = f$. We could then use the expansions

$$\psi(\mathbf{x}) = \sum_{\mathbf{r}} (a_{\mathbf{r}} + ib_{\mathbf{r}}) \phi_{\mathbf{r}}(\mathbf{x}),$$

$$|\psi(\mathbf{x})|^2 = \sum_{r,s} (a_r a_s + b_r b_s) \phi_r \phi_s$$

and extend the methods of §§6 and 9 in the obvious way for estimating the coefficients. Here the ϕ_r could be either the Hermite functions or the eigenfunctions of the specific Schrödinger equation. It might be worth noting that $\nabla^2 \phi_r$ can be rewritten by Schrödinger's equation.

APPENDIX A. Proof of equations (17) and (18), and multivariate extensions

We have

$$\int {\gamma'}^2 dx = \sum_{r,s} \gamma_r \gamma_s \int {\phi_r}' {\phi_s}' dx$$

$$= \sum_{r,s} \gamma_r \gamma_s \int \{ (2r)^{1/2} {\phi_{r-1}} - x {\phi_r} \}$$

$$\cdot \{ (2s)^{1/2} {\phi_{s-1}} - x {\phi_s} \} dx$$
 (44)

and (17) quickly follows from the orthogonality of $\{\phi_m\}$ combined with (65) of Appendix E, and (Margenau & Murphy, 1943, p. 361)

$$\int x^{2} \phi_{m}(x) \phi_{n}(x) dx$$

$$= \left(\frac{1}{2} + m\right) \delta_{m}^{n} + \frac{1}{2} \left\{ m(m-1) \right\}^{1/2} \delta_{m}^{n+2} + \frac{1}{2} \left\{ n(n-1) \right\}^{1/2} \delta_{m+2}^{n}. \tag{45}$$

A proof of equation (18) along these lines occupies several pages, but, as we noted, there is a short-cut that uses some of the formalism of quantum mechanics which we now describe. There is a similar short-cut for the above proof, but it does not save much work in this case and the above calculation will serve as a check.

The right side of (18) is a quadratic form in an infinite number of variables with a matrix Q whose elements are

$$\int \phi_r'' \phi_s'' \ dx = \int \phi_r \left(i \frac{\partial}{\partial x} \right)^4 \phi_s \ dx. \tag{46}$$

In accordance with the equivalence of Schrödinger's and Heisenberg's formulations of the quantum mechanics of the harmonic oscillator (Schrödinger, 1926), Q must be the fourth power of the Hermitian momentum matrix

and can be quickly calculated.

For completeness and for convenience in generalization, we here give a proof of the required identities. We wish to prove that, for each $m \geq 0$, the matrix

$$\left\{ \int \phi_r \left(\frac{d}{dx} \right)^m \phi_s \ dx \right\} = \left\{ \int \phi_r \phi_s' \ dx \right\}^m, \tag{48}$$

where r and s index the rows and columns of the matrices, i.e. the matrix on the left hand side is expressed as the mth power of a matrix. For m = 0 this merely expresses the normal orthogonality of the Hermite functions. To prove (48) it is sufficient to prove that for each pair of positive integers m and n we have

$$\int \phi_r \left(\frac{d}{dx}\right)^{m+n} \phi_s \ dx = \sum_{t=0}^{\infty} \int \phi_r(x) \left(\frac{d}{dx}\right)^m \phi_t(x) \ dx$$

$$\cdot \int \phi_t(y) \left(\frac{d}{dy}\right)^n \phi_s(y) \ dy. \tag{49}$$

By means of a number of partial integrations, together with some inversions of the orders of integration and summation, we can write the required identity in the form

$$\int \frac{d^m \phi_r}{dx^m} \frac{d^n \phi_s}{dx^n} dx$$

$$= \iint \frac{d^m \phi_r(x)}{dx^m} \frac{d^n \phi_s(y)}{dx^n} \sum_t \phi_t(x) \phi_t(y) dx dy, \qquad (50)$$

and this is formally correct since physicists opine that

$$\sum_{t} \phi_t(x)\phi_t(y) = \delta(x - y). \tag{51}$$

Equation (51) is an example of the closure property of a complete orthonormal system; see, for example, Messiah (1961, pp. 187, 492).

Messiah (1961, pp. 187, 492). Formally the identity (51) holds for any complete orthonormal system, not merely for the Hermite functions. For the Hermite functions, the argument can be made rigorous by putting in a convergence factor $z^t(|z|) < 1$), making use of Mehler's formula

$$\sum_{t=0}^{\infty} z^{t} \phi_{t}(x) \phi_{t}(y) = \frac{1}{\pi^{1/2} (1 - z^{2})^{1/2}} \cdot \exp\left\{ \frac{4xyz - (x^{2} + y^{2})(1 + z^{2})}{2(1 - z^{2})} \right\}, \quad (52)$$

see, for example, Erdélyi et al. (1953, p. 194); Wiener (1933, p. 62); Watson (1933), and finally letting $z \rightarrow 1 - 0$.

Rigour can also be attained by using the Christoffel-Darboux formula (see Appendix F), but the use of Mehler's formula has the advantage that it can be generalized to the multivariate case; see for example, Erdélyi (1938), who gives further references to Koschmieder.

In this appendix we shall use the following multivariate notations:

$$\mathbf{m} = (m_1, m_2, \dots, m_p)',$$

$$|\mathbf{m}| = m_1 + \dots + m_p, \quad \mathbf{m}! = m_1! \ m_2! \cdots m_p!,$$

$$\delta_{\mathbf{m}}^{\ n} = \delta_{\mathbf{m}}^{\ n_1} \cdots \delta_{\mathbf{m}}^{\ n_p}, \quad \mathbf{a}^{\ b} = a_1^{\ b_1} \cdots a_p^{\ b_p},$$

where a is a vector. The same convention applies if a is replaced by a vector matrix defined as $A = (A_1, \dots, A_p)$, where A_1, \dots, A_p are commutative matrices. The matrix A can be regarded as a vector whose components are matrices and also as a matrix whose elements are vectors. The convention also applies to differentiation, that is,

$$\nabla^{\mathbf{m}} = \left(\frac{d}{d\mathbf{x}}\right)^{\mathbf{m}} = \left(\frac{\partial}{\partial x_1}\right)^{m_1} \cdots \left(\frac{\partial}{\partial x_p}\right)^{m_p}$$

The definitions of the multivariate Hermite polynomials are (see, for example, Erdélyi *et al.* (1953, p. 285))

$$H_{\mathbf{r}}(\mathbf{x}) = H_{\mathbf{r}}(\mathbf{x} \mid \mathbf{C}) = (-1)^{|\mathbf{r}|} \exp\left(\frac{1}{2}\mathbf{x}'\mathbf{C}\mathbf{x}\right)$$
$$\cdot \left(\frac{d}{d\mathbf{x}}\right)^{\mathbf{r}} \exp\left(-\frac{1}{2}\mathbf{x}'\mathbf{C}\mathbf{x}\right), \quad (53)$$

$$G_{\rm r}({\bf C}^{-1}{\bf x}) = G_{\rm r}({\bf C}^{-1}{\bf x} \mid {\bf C}) = H_{\rm r}({\bf x} \mid {\bf C}^{-1}),$$
 (54)

where $\mathbf{C} = (c_{ij})$ is a positive definite real $p \times p$ matrix. The factor $\frac{1}{2}$ in the index of the exponential is a convention differing from our convention for the case p = 1. Then the functions $\phi_r(\mathbf{x})$ and $\chi_r(\mathbf{x})$ defined by

$$\frac{\phi_{\rm r}({\bf x})}{H_{\rm r}({\bf x})} = \frac{\chi_{\rm r}({\bf x})}{G_{\rm r}({\bf x})} = \frac{\exp{(-\frac{1}{4}{\bf x}'C{\bf x})}}{(2\pi)^{p/4} ||C||^{1/4} \sqrt{({\bf r}!)}}$$
(55)

form a normal biorthogonal system, that is,

$$\int \phi_{\rm r}({\bf x}) \chi_{\rm s}({\bf x}) \ d{\bf x} = \delta_{\rm r}^{\rm s}. \tag{56}$$

The multivariate form of (48) is

$$\left\{ \int \phi_{\rm r} \nabla^{\rm m} \chi_{\rm s} \ d\mathbf{x} \right\} = \left\{ \int \phi_{\rm r} \nabla \chi_{\rm s} \ d\mathbf{x} \right\}^{\rm m}, \qquad (57)$$

where the right side is the mth power of a vector matrix. It has a definite meaning because the relevant

scalar matrices commute. This corresponds to the quantum-mechanical fact that components of momentum commute, and it also follows from the proof of (57) along the lines of that of the scalar case, rigour being provided by the Koschmieder-Erdélyi generalization of Mehler's formula.

The univariate argument of Margenau & Murphy (1943, pp. 120–121) can be conveniently generalized by using the multivariate notation. After some manipulation, we obtain

$$\int x_{i}\phi_{r}(x)\chi_{s}(x) dx = \delta_{r}^{s+e_{i}}r_{i}^{1/2} + \delta_{r+e_{i}}^{s} s_{i}^{1/2}$$
 (58)

where e_i is the vector whose components are all 0 except the *i*th which is 1. This generalizes (65) of Appendix E. But clearly

$$\frac{\partial \phi_{\rm r}}{\partial x_i} = \frac{1}{2} \phi_{\rm r} \sum_i c_{ii} x_i - (r_i + 1)^{1/2} \phi_{\rm r+e_i}, \qquad (59)$$

so the skew-symmetric matrix

$$\left\{ \int \phi_{\mathbf{r}} \frac{\partial}{\partial x_{i}} \chi_{\mathbf{s}} d\mathbf{x} \right\} = -\left\{ \int \chi_{\mathbf{s}} \frac{\partial}{\partial x_{i}} \phi_{\mathbf{r}} d\mathbf{x} \right\}$$
 (60)

can be evaluated. Then (57) can be used to evaluate the penalty (28) by first writing

$$\gamma = \sum_{r} \gamma_r \phi_r = \sum_{r} \delta_r \chi_r$$

The calculations could be checked by noting that

$$\left\{ \int x^{\mathbf{m}} \phi_{\mathbf{r}}(\mathbf{x}) \chi_{\mathbf{s}}(\mathbf{x}) \ d\mathbf{x} \right\} = \left\{ \int x \phi_{\mathbf{r}}(\mathbf{x}) \chi_{\mathbf{s}}(\mathbf{x}) \ d\mathbf{x} \right\}^{\mathbf{m}} = \mathbf{M}^{\mathbf{m}}$$

(61)

say, which generalizes Margenau & Murphy (1943, p. 361), combined with repeated use of (59). Here (61) is the position analogue of the momentum identity (57). The characteristic function of f is $\gamma'e^{itm}\delta$, where γ and δ are the vectors with components γ_r and δ_s .

The remarkable identities (48) and (57) can be used more generally for the convenient evaluation of $\int (D\gamma)^2 dx$, where D is any linear differential operator. This remark should be of use in the theory of spline interpolation as well as for trying out other roughness penalties.

APPENDIX B. Example of a hand solution of (20) and (21)

In equations (20) and (21) with $\alpha = \frac{1}{4}$ and $\beta = 0$, take N = 1, $x_1 = 0$ and $\gamma_k = 0$ for $k \ge 4$. Then the equations become $\gamma_0^2 + \gamma_1^2 + \gamma_2^2 + \gamma_3^2 = 1$ and

$$\frac{2\phi_k(0)}{\sum_{s=0}^{3} \gamma_s \phi_s(0)} + \{(k+1)(k+2)\}^{1/2} \gamma_{k+2} = (2k+2\lambda)\gamma_k$$

$$-\left\{(k-1)k\right\}^{1/2}\gamma_{k-2} \qquad (k=0,1,2,3).$$

These equations are satisfied by taking $\lambda = 1$, $\gamma_0 = 1$ and $\gamma_1 = \gamma_2 = \gamma_3 = 0$ because $\phi_0(0) = \pi^{-1/4}$,

 $\phi_2(0) = -\pi^{1/4}\sqrt{2}$ and $\phi_1(0) = \phi_3(0) = 0$. *We have also found by a computer run that the same solution is obtained when $\alpha = 0$, $\beta = \frac{1}{3}$.*

APPENDIX C. Invariance of f/\sqrt{g}

The reader should look at §10 and compare it with Good (1968b, 1969).

If a nonsingular transformation $x = h(\xi)$ and y = h(n) is made, where h is some twice differentiable vector function, the same for both x and y, then of course

$$v(x, y) = v\{h(\xi), h(n)\} = v^*(\xi, n),$$

where v^* refers to the new co-ordinates. We have

$$\frac{\partial v^*(\xi, \mathbf{n})}{\partial \eta_i} = \sum_{\mu} \left(\frac{\partial v(\mathbf{x}, \mathbf{y})}{\partial x_{\mu}} \cdot \frac{\partial x_{\mu}}{\partial \eta_i} + \frac{\partial v(\mathbf{x}, \mathbf{y})}{\partial y_{\mu}} \frac{\partial y_{\mu}}{\partial \eta_i} \right) \\
= \sum_{\mu} \frac{\partial v(\mathbf{x}, \mathbf{y})}{\partial y_{\mu}} \cdot \frac{\partial y_{\mu}}{\partial \eta_i} ,$$

$$\frac{\partial^2 v^*(\xi, \mathbf{n})}{\partial \eta_i \partial \eta_j} = \sum_{\mu, \nu} \frac{\partial^2 v(\mathbf{x}, \mathbf{y})}{\partial y_\mu \partial y_\nu} \frac{\partial y_\mu}{\partial \eta_i} \frac{\partial y_\nu}{\partial \eta_j}$$

$$+ \sum_{\mu} \frac{\partial v(\mathbf{x}, \mathbf{y})}{\partial y_{\mu}} \frac{\partial^{2} y_{\mu}}{\partial \eta_{i} \partial \eta_{i}}$$

At y = x, the second summation vanishes because v(x, y), as a function of y, has a maximum at y = x when truth is the best policy. Hence

$$\left[-\frac{\partial^2 v(\mathbf{x}, \, \mathbf{y})}{\partial y_i \, \partial y_j} \right]_{\mathbf{y} = \mathbf{x}}$$

is a covariant tensor of rank 2. The sign in Good (1968b) was misprinted. It also follows that

$$g(\mathbf{x})\left(\frac{\partial \mathbf{x}}{\partial \xi}\right)^2 = g^*(\xi),$$

where $\partial x/\partial \xi$ denotes a Jacobian. If g(x) never vanishes, then $\{g_{ij}\}$ is positive definite and $f(x)/\{g(x)\}^{1/2}$ is invariant; recall that f is a density function so that $f(x) \partial x/\partial \xi = f^*(\xi)$.

APPENDIX D. An intuitive constraint on α and β

An intuitively reasonable constraint on α and β will be derived here, namely

$$2\alpha\sigma^2 + \frac{3}{4}\beta = \sigma^4, \tag{62}$$

where σ^2 is either an initially guessed value of the variance or an estimate from the sample x_1, \dots, x_N . In our numerical work we standardized the sample variance to $\frac{1}{2}$ so that (62) could be written

$$4\alpha + 3\beta = 1. \tag{63}$$

Some pairs of values that satisfy (63) are $(\frac{1}{4}, 0)$, $(0, \frac{1}{3})$ and $(\frac{1}{8}, \frac{1}{6})$, and these were emphasized in our numerical work. Of all pairs of values for α and β that satisfy the constraint, the simplest are the first two of these pairs, and $(0, \frac{1}{3})$ gave good results in all our computer runs.

The basis for the constraint (62) is the feeling

that the normal distributions form the smoothest class of distributions, the improper uniform distribution being a limiting form. Perhaps some justification for this feeling is that a normal distribution is the distribution of maximum entropy for a given mean and variance (Shannon, 1948, p. 629). This is not convincing because the result is different when more moments are given (Good, 1963, p. 915). The integral $\int \gamma'^2 dx$ is also minimized for a given variance when f is normal; see Appendix E. In any case it seems reasonable to give the normal distribution special consideration. We therefore prefer α and β to be such that, when f is normal, the score $\omega(\alpha, \beta; f)$ is maximized by taking the mean and variance of f equal to \bar{x} and $\Sigma(x_i - \bar{x})^2/(N-1)$.

If
$$f(x) \sim \mathfrak{N}(\mu, \sigma^2)$$
, we have

$$\int \gamma'^2 dx = 1/(4\sigma^2), \qquad \int \gamma''^2 dx = 3/(16\sigma^4), \quad (64)$$

and therefore

$$\omega(\alpha, \beta; f) = -N \log (\sigma 2^{1/2} \pi^{1/2})$$
$$- \sum_{i=1}^{N} \frac{1}{2} (x_i - \mu)^2 / \sigma^2 - \alpha / \sigma^2 - 3\beta / (16\sigma^4).$$

This is maximized by taking $\mu = \bar{x} = \Sigma x_i/N$ and σ such that

$$-N/\sigma + \Sigma(x_i - \bar{x})^2/\sigma^3 + 2\alpha/\sigma^3 + 3\beta/(4\sigma^5) = 0.$$

This implies the constraint (62) if we put $\sigma^2 = \sum (x_i - \bar{x})^2/(N-1)$.

The main weakness in the above argument is that it assumes we know that the true population is normal, but if we knew this we would not wish to use a nonparametric method for density estimation. Accordingly, although we did obtain smooth fits in all the original runs when we took $\beta = 1/3$, it is not very surprising that other values of β were found to lead to the best fits to the true density functions in the numerical examples reported in Section 7A, even when the true density function was normal. Nevertheless it is worth noting how the above method can be generalized for parametric density estimation, namely the estimation of a vector parameter 0 in a family of density functions $f(x \mid \theta)$. For such a density function the total score ω would become a function of θ , α and β . The maximization of this score would lead to a value of θ , say $\hat{\theta}$, and to a constraint on the values of α and β that seems to us intuitively natural. Of course, when it is assumed that $\alpha=0$, as we have decided is adequate, this method would usually lead to a specific value of β . This value would usually depend on the sample, as well as on the underlying parametric family of density functions. If the value of 0 obtained by the maximization were also accepted, namely $\hat{\theta}$, our method would reduce to a parametric method of density estimation which we believe deserves further investigation. The method described here has been called the method of Type II maximum likelihood (Good, 1967). We repeat that it is a parametric method unlike the methods treated in detail in the rest of this paper. The possibility of using a significance test for the components of θ , based on the Type II Likelihood Ratio (Good, 1967), should also be borne in mind.

Appendix E. A penalty for large variance and some lower bounds for the roughness penalty

If we have some initial impression of how large the variance of our distribution should be and also if we estimate σ^2 from the sample, we might wish to take a penalty for any hypothesis with too large or too small a variance. Note that the variance can be expressed in terms of the γ 's, by using equation (45) together with the simpler formula

$$\int x\phi_m(x)\phi_n(x) \ dx = \left(\frac{1}{2}m\right)^{1/2} \ \delta_m^{n+1} + \left(\frac{1}{2}n\right)^{1/2} \ \delta_{m+1}^{n} \ . \tag{65}$$

We obtain

$$E(x) = \sqrt{2} \sum \gamma_m \gamma_{m+1} (m+1)^{1/2}.$$
 (66)

$$\operatorname{var}(x) = \sum (m + \frac{1}{2}) \gamma_m^2 + \sum \gamma_m \gamma_{m+2} \{ (m+1)(m+2) \}^{1/2} - 2 \{ \sum \gamma_m \gamma_{m+1} (m+1)^{1/2} \}^2.$$
 (67)

These formulae are of interest apart from the possible use of (67) for a new roughness penalty. We should have printed these values in our computer runs. They can be generalized to p dimensions by

If the roughness penalty were taken proportional to var (x) the effect would be that f would vanish outside the range of the observations and would therefore be discontinuous. This would be unreasonable, but it might be worth while to consider using this penalty, or one proportional to the generalized variance in p dimensions, as an *addition* to the penalties considered in the main text. This would enable our dislike of large variance, which we used in §7, to be taken into account quantitatively. An invariant form of this penalty could perhaps be devised by regarding Ricmannian co-ordinates (Weatherburn, 1938, p. 79) with the pole at \bar{x} as the most natural; but \bar{x} depends on the co-ordinates used so it would have to be found iteratively and might not be unique.

For p=1, a penalty for small variances, and other moments, is already implicit in (13). For if we assume γ , γ' , γ'' , \cdots tend to 0 at ∞ , and write

$$\mu_{r}' = \int x^{r} f(x) dx$$
 $(r = 0, 1, 2, \cdots),$

we can prove that

$$\int \gamma'^2 dx \ge \frac{r^2 \mu_{r-1}'^2}{4\mu_{2r}'}, \qquad \int \gamma''^2 dx \ge \frac{r^4 \mu_{r-1}'^4}{16\mu_{2r}'^2}, \quad (68)$$

and in particular

$$\int \gamma'^2 dx \ge \frac{1}{4\mu_2'^2} , \qquad \int \gamma''^2 dx \ge \frac{1}{16\mu_2'^4} . \tag{69}$$

The first of the inequalities (69) is essentially equivalent to a form of the uncertainty principle; see for example, Weyl (1931, p. 393). It becomes an equality when f is normal. All these inequalities can be proved by using partial integrations and Schwartz's inequality.

The corresponding multivariate inequalities are

$$4 \int (\nabla \gamma)^{2} d\mathbf{x} \ge (\mu_{200...}')^{-2} + (\mu_{0200...}')^{-2} + \cdots,$$

$$(70)$$

$$16 \int \Sigma \left[\frac{\partial^{2} \gamma}{\partial x^{2}} \right]^{2} d\mathbf{x}$$

Appendix EA. The maximum possible value for the roughness penalty

 $\geq (\mu_{200...}')^{-4} + (\mu_{0200...}')^{-4} + \cdots$

*If the Hermite expansion is truncated after the rth term, $\gamma_{r-1}\phi_{r-1}(x)$ then the maximum possible value for $\Phi(f)$, as defined by (13), can be calculated. We shall here consider only the maximum values of $\int \gamma'^2 dx$ and $\int \gamma''^2 dx$.

By (18), the largest value of the estimate of $\int \gamma''^2 dx$ that can be reached, if the series is truncated at m = r - 1, is the maximum eigenvalue of the matrix Q_r of order r in the north-west corner of the matrix Q defined in Appendix A. Some of these eigenvalues were computed and are given by the following table.

For r > 50, the maximum value of $\int \gamma''^2 dx$ (the maximum eigenvalue of Q_r) can be approximated as one quarter of the fourth power of the largest eigenvalue of the corresponding north-west corner of

$$\begin{bmatrix} 0 & 1 & 0 & 0 & \cdots \\ 1 & 0 & \sqrt{2} & 0 & \cdots \\ 0 & \sqrt{2} & 0 & \sqrt{3} & \cdots \\ 0 & 0 & \sqrt{3} & 0 & \cdots \\ & & & & & & & & \\ & & & & & & & \\ \end{bmatrix}.$$
 (71.1)

(The changes of sign from (47) are immaterial.) This is to be expected and is supported by numerical

evidence. For example, the true value of the maximum eigenvalue of Q_r (as given by Table 3), divided by this approximate value, is 1.41 when r=10, 1.24 when r=15, and 1.17 when r=20, fairly obviously tending to 1 as $r\to\infty$. Moreover the characteristic polynomial of the north-west $r\times r$ corner of matrix (71.1) can be shown to be $(-1)^rH_r(\kappa/\sqrt{2})2^{-r/2}$. The largest root of $H_r(x)$ is less than and, for r>5, within 0.05 of

$$(2r+1)^{1/2}-1.85575(2r+1)^{-1/6}$$
 (71.2)

(Szegö, 1959, p. 132). For example, the largest root of $H_{20}(x)$ is 5.387 (Salzer *et al*, 1952, quoted by Abramowitz and Stegun, 1965, p. 924), whereas (71.2) with r=20 is 5.404. Thus we can approximate within about 10% to the largest possible value of the estimate of $\int \gamma''^2 dx$ for any given value of r>50, even without tables of the roots of the Hermite polynomials.

It might be possible to obtain more explicit information about the maximum eigenvalue of Q_r , in terms of elementary functions and Hermite polynomials, for we have found some related simple formulae. First, the determinants are given by

$$|Q_0| = 1,$$
 $16 |Q_{2r}| = (4r + 3)(4r + 5) |Q_{2r-1}|,$ $\frac{3}{4} |Q_{2r-1}| = (r!)^4 \prod_{r=1}^{r} \left(1 - \frac{1}{4s^2}\right)^2.$ (71.3)

This was found by computation for r = 1(1)(15) and must surely always be true. Second, the corresponding eigenvalue problem for $\int \gamma'^2 dx$ is fully solved in that the corresponding $r \times r$ matrix can be seen (non-trivially) to have characteristic polynomial equal to

$$\frac{(-1)^r}{2^{2r+1}\sqrt{\kappa}}H_r(\sqrt{\kappa})H_{r+1}(\sqrt{\kappa}). \tag{71.4}$$

Thus the maximum possible value of $\int \gamma'^2 dx$, when the Hermite expansion is truncated after r terms, is equal to the square of the largest root of $H_{r+1}(x)$. So there is perhaps a similar neat formula for the maximum integral of the square of the second derivative.*

TABLE 3 $\textit{Maximum eigenvalues of } Q_\tau \textit{ or of } \int \gamma''^2 \textit{ dx}$

(71)

1 0.75	2 3.75	3 10.2	4 20.9	5 36.4	6 57.0	7 83.1	8 114.8	9 152.3	10 195.9	2
11 245.6	12 301.6	13 363.9	14 432.6	15 507.9	16 589.7	17 678.1	18 773.2	19 875.1	20 938.7	
21 1099	22 1221	23 1351	24 1487	25 1630	26 1780	27 1937	28 2101	29 2272	30 2451	
31 2636	32 2829	33 3028	34 3235	35 3449	36 3670	37 3899	38 4134	39 4377	40 4627	
41 4884	42 5149	43 5421	44 5700	45 59 87	46 6280	47 6582	48 6890	49 7206	50 7529	

APPENDIX F. Sufficient conditions for $\gamma(x) = \sum_{\gamma_m \phi_m(x)} \alpha_m(x)$ and for its differentiation

We have (for example, Erdélyi et al. (1953, p. 193) and Jackson (1941, p. 158)),

$$\sum_{r=0}^{n} \phi_r(x)\phi_r(y) = \psi_n(x, y), \tag{72}$$

where

$$\psi_n(x, y) = \frac{\phi_{n+1}(x)\phi_n(y) - \phi_{n+1}(y)\phi_n(x)}{x - y} \left\{ \frac{1}{2}(n+1) \right\}^{1/2}.$$
(73)

This is a special case of the Christoffel-Darboux identity (Szegö, 1959, p. 43). Therefore

$$\sum_{r=0}^{n} \gamma_r \phi_r(x) = \int_{-\infty}^{\infty} \gamma(y) \sum_{0}^{n} \phi_r(x) \phi_r(y) dy$$
$$= \int_{-\infty}^{\infty} \gamma(y) \psi_n(x, y) dy. \tag{74}$$

Let us assume that the derivatives $\gamma'(x)$, $\gamma''(x)$, \cdots , as far as the sth derivative, tend to 0 when $x \to \pm \infty$, and that γ and each relevant derivative is of bounded variation in each finite interval and is absolutely integrable in $(-\infty, \infty)$. We can then differentiate (74) s times, and after s partial integrations, we obtain

$$\sum_{r=0}^{n} \gamma_{r} \phi_{r}^{(s)}(x) = (-1)^{s} \int_{-\infty}^{\infty} \gamma^{(s)}(y) \psi_{n}(x, y) dy$$

$$(s = 0, 1, 2, \cdots). \tag{75}$$

Now (Plancherel & Rotach, 1929) if $x \neq 0$ and n is large,

$$\phi_n(x) = \frac{2^{1/4}}{n^{1/4} \sqrt{\pi}}$$

$$\cdot \left[\cos \left\{ \frac{1}{2} (n+1)\pi - x(2n)^{1/2} \right\} + O(n^{-1/2}) \right]. \tag{76}$$
Therefore

$$\sum_{r=0}^{n} \gamma_{r} \phi_{r}^{(s)}(x)$$

$$= \frac{1}{\pi} \int_{-\infty}^{\infty} \frac{\gamma^{(s)}(y) \sin \{(x-y)(2n)^{1/2}\}}{x-y} dy + O\left(\frac{1}{\sqrt{n}}\right);$$
(77)

see, for s=0, Szegö (1959, p. 245). By the Riemann-Lebesgue theorem, when $n \to \infty$ the integral depends only on values of $\gamma^{(s)}(y)$, where y is in the neighbourhood of x. It follows that

$$\sum_{r=0}^{\infty} \gamma_r \phi_r^{(s)}(x) = \gamma^{(s)}(x) \qquad (s = 0, 1, \dots).$$
 (78)

When x = 0, one could base the proof on the asymptotic formula (2) of Erdélyi *et al.* (1953, p. 199).

For the multivariate case this argument does not generalize, but the series (78) can be shown to be

summable in Abel's sense (Hardy, 1949) by using Mehler's identity (52) and this result can be generalized by using the generalization of Mehler's identity mentioned in Appendix A. The multivariate notation z^m gives the appropriate generalization of Abel summability.

*APPENDIX G. More general roughness penalties.

We have already referred to the practicability of using roughness penalties of the general form $\int (D_{\gamma})^2 dx$ where D is a linear differential operator. It would also be practicable to use roughness penalties of the even more general form $\Psi\{\int (D_{\gamma})^2 dx\}$ where Ψ is a smooth function of a real variable. It was natural to start with the simplest of such roughness penalties, but it is worth noting the wide class of generalizations potentially available. But it is doubtful whether such generalizations should be used without good reason.*

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Longitudinal Distribution and Habitat of the Fishes of Mason Creek, an Upper Roanoke River Drainage Tributary, Virginia

Abstract-Mason Creek is an Order 4 tributary of 15.0 miles in length within the upper Roanoke drainage, Virginia. Based on a total of 16 collections from seven localities and on personal communications, its present ichthyofauna includes 40 species distributed among seven families. The fauna is typical of that of the upper Roanoke drainage. Faunal diversity (number of species) increased regularly from the headwaters to the mouth, from six species at the uppermost station to 31 at the lowermost. The dominant trend was addition of species, rather than replacement, in the downstream direction. Most species showed a pattern of longitudinal zonation, disappearing in the upstream direction after apparently being continuously distributed, or they appeared only in the headwaters. Few species were collected at all stations. Thirty-two species were recorded in pools and 12 in riffles. Generally, only the larger individuals of typically pool-inhabiting forms were found in swifter waters, and the young of species whose adults are riffle fishes frequented quieter waters.

Introduction

The Roanoke River drainage, Virginia and North Carolina, probably has the most diverse and distinctive fish fauna of all drainages on the Atlantic slope of the United States (1). Little, however, has been published on the longitudinal distribution patterns and habitat of many of its non-game fishes. Baseline information on these aspects of distribution is generally important for assessing effects of stream alteration by pollution, channelization and other factors.

Early records of fishes from the upper Roanoke drainage were given by Cope (2) and Jordan (3), but in most cases specific localities of capture and habitat were not mentioned. In pollution-related studies, Jackson and Henderson (4) and Cairns, et al. (5) tabulated by locality the fishes collected

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from a series of stations along part of the main upper Roanoke River. Their results largely showed marked effects of stream pollution in the Roanoke-Salem cities area (see also McGauhey and Eich (6)), as relatively little natural faunal change probably occurs in that river section. The Roanoke River ichthyofauna in the Salem area has recently recovered to a great extent owing to reduction of pollution, but it remains depleted in the Roanoke area.

Mason (or Masons) Creek, a moderate-size tributary of the upper Roanoke in the Salem area, southcentral Virginia, was selected for our study because a major landfill has been proposed for a portion of its basin, and from preliminary survey it appeared to have a fish fauna typical of that of relatively unpolluted sections of the upper Roanoke drainage. The magnitude of faunal changes per stream mile in streams the size of Mason Creek may be generally greater than those in larger streams such as Roanoke River in the Roanoke-Salem area. A total of 16 collections from seven localities are documented. Included in the discussion is a summary of the composition of the upper Roanoke drainage ichthyofauna, from Salem upstream.

Methods

Seven stations, numbered in order progressing upstream, were selected for their accessibility, habitat diversity, and to achieve representation of fairly evenly spaced areas of the creek (Fig. 1). All have riffles, runs and pools with various proportions of bottom materials ranging from silt to boulder or bedrock. Runs are considered to be areas intermediate in habitat between riffles and pools; they have a moderate to fairly swift current, differing from riffles by generally being deeper, less turbulent, and having smaller bottom materials.

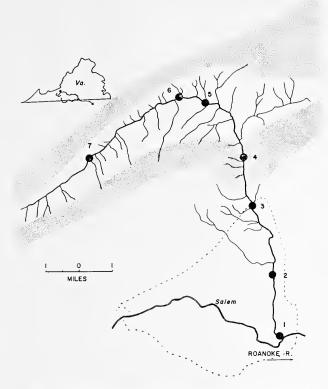


Fig. 1—Map of Mason Creek system. Closed circles indicate collecting stations. Stipple indicates mountain ridges. City of Salem outlined by dashed line. Western limit of City of Roanoke is about one mile east of Salem. Mason Creek area indicated by dot on inset map.

The vast majority of the fishes collected were taken with 10 foot, 1/4 inch mesh seines. Deeper, boulder-filled and well-sheltered areas at Stations 1 and 3 were also electrically shocked with a Smith-Root Type V Electrofisher (325-425 volt pulsed DC). Each habitat at all stations was worked in the fall of 1969 with an intensity and strategy judged sufficient to collect most or all species present. Low water conditions during most collections enhanced success. Additional collections by us and others provided supplemental data. The term "faunal diversity" refers to the total number of species. Relative abundance of species and their habitat occurrence (Table I) were subjectively assessed in the field, by identification of adults and juveniles of all species and the young of most species when they were collected. Many individuals of the more common species were released, permitting more collecting time. Specimens are stored in 45% isopropyl alcohol at Roanoke College.

The U. S. Geological Survey 15 minute series, 1:62500 scale Salem 1932 topographic quadrangle served as the base map for Figure 1 and for location or determination of geomorphic features and stream parameters. Drainage area was determined with the aid of a planimeter, and stream mileage with a map tracer. The total relief of the creek is the vertical elevation rise between the mouth and the most upstream point on the main channel where two first

order streams merge (7). Stream order was determined by Strahler's modification of the Horton system (8). Average width and depth were determined as outlined by Lagler (9). Three width measurements each of a pool and a riffle were made at each station measured. Three depth readings were taken at each width transect. Discharge was determined by a timed float method (10).

For pH determinations, water samples were placed in a temperature insulated container and analyzed shortly after in the laboratory with a Photovolt Model 115A pH meter. Dissolved oxygen was determined in the field with a YSI Model 54 oxygen meter. Other chemical determinations were made in the field or laboratory with the following Hach chemical kits: AC-5, AL-5P, CA-23, CU-4, NI-8, NI-10, PO-24.

The recent list (5) of fishes from the Roanoke River in the Salem area includes several misidentifications or errors; where preserved specimens are available at Virginia Polytechnic Institute and State University, the records (except from station 2) are corrected under the appropriate species in the Annotated List herein. Further comment on fishes from station 2 is not made herein since the species list and numbers of specimens (for VPI collection number 2515) differs greatly from that published. The summary (5) of fishes said to have been taken from the upper Roanoke River by Jordan (3) and in 1952 by E. C. Raney and R. D. Ross actually includes records from tributaries.

Stations and Collections

- 1. Mile 0.0–0.6. Collection 1a: 3 Oct. 1969, REJ 346 (Jenkins' collection number); Collection 1b: 1 Oct. 1970, REJ 405; Collection 1c: 15 Nov. 1971, REJ 524.
- 2. Mile 2.0–2.2. Collection 2a: 31 March 1940, E. C. Raney 705; Collection 2b: 5 Sept. 1947, E. A. Lachner 503; Collection 2c: 20 Oct. 1969, REJ 354.
- 3. Mile 4.1–4.6. Collection 3a: 5, 7 May 1969, REJ 316; Collection 3b: 10 Sept. 1969, REJ 334; Collection 3c: 1 Nov. 1971, REJ 512.
- 4. Mile 5.8-6.0. Collection 4a: 30 Sept. 1969, CAF (Freeman) 1; Collection 4b: 9 Oct. 1969, CAF 5.
- 5. Mile 8.1–8.2. Collection 5a: 7 Oct. 1969, REJ 347; Collection 5b: 8 Nov. 1971, REJ 514.
- 6. Mile 9.0–9.1. Collection 6: 15 Oct. 1969, REJ 353.
- 7. Mile 12.5–12.6. Collection 7a: 15 Oct. 1969, REJ 352; Collection 7b: 8 Nov. 1971, REJ 513.

Description of Creek and Basin

Mason Creek, located in Roanoke County, south-central Virginia (Fig. 1), is an Order 4 stream of 15.0 miles in length. It is generally shallow and ranges 20–40 feet in width near its mouth. Width, depth and discharge at four stations are given in Table II; the discharge at Station 1 was determined during a period of slightly subnormal water level, whereas when measured at the other stations the levels were slightly above normal. In October 1969

Distribution, abundance and habitat of Mason Creek fishes (Habitat based on capture of juveniles and adults. Stream mile is that of middle of station. A = abundant, C = common, U = uncommon, R = rare, * = occurs but not taken in habitat during this study.)

	1	2	3	Station 4	5	6	7			
Species	0.3	2.1	4.4	Stream M 5.9		9.0	15.5	Pool	Habitat Run	Riffle
Moxostoma ariommum Ictalurus nebulosus Notropis analostanus Notropis ludsonius Percina rex Micropterus salmoides Moxostoma erythrurum Moxostoma rhothoecum Etheostoma podostemone Moxostoma cervinum Percina crassa Exoglossum maxillingua Micropterus dolomieui Notropis volucellus Pimephales notatus Notropis albeolus Lepomis macrochirus Notrus insignis Ambloplites rupestris Notropis ardens Etheostoma nigrum Lepomis auritus Notropis cerasinus Notropis cerasinus Notropis procne Notropis cerasinus Notropis procne Catostomus commersoni Lepomis gibbosus Hypentelium nigricans Esox niger Canpostoma anomalum Etheostoma flabellare Phoxinus oreas Clinostomus funduloides Rlinichthys atratulus Semotilus atromaculatus	R R U C R R U A R U R R U C C U U U A C C C C C C U R — C C R	R R U R C C C U U C C U C C C C C C C C	UCUU CC R ACCUCAC RCCCC	RUCURRACCCCU — UU — U	R C R C A R C C C U A A C	U R U R C U U U U	U C A A C C	R R U C R R U — — R U U R C C U U U U A C C C C C C C R C C U A C C C	*	R
Total species: 35	31	24	19	16	13	10	6	32	19	12

the creek was intermittent in a few sections between stations 6 and 7, and residents reported that surface water is absent at station 7 during periods of very low water table. The Roanoke area has an average annual rainfall of 41.2 inches.

The creek drains an asymmetrical basin of 29.4 square miles. Large tributaries are lacking. It is a northern tributary of the upper Roanoke River. Minor Roanoke River tributaries drain the area east and west of the lower portion of the creek. It heads against Bradshaw Creek, a tributary of North Fork Roanoke River. Paralleling upper Mason Creek to the North is Catawba Creek, a major tributary of the upper James River.

The basin is in the Ridge and Valley physiographic province. The lower four miles of the creek flow in an area of the Roanoke Valley having slight to moderate relief. Stream miles 4.5–6.5 occupy a very narrow gap in the Hanging Rock-Bennett Springs area, between Fort Lewis Mountain on the West and

Brushy Mountain and Green Ridge on the East. The valley widens above the gap into Mason Cove, which is bounded on the South largely by Fort Lewis Mountain (highest point 3272 feet) and, on the North, by Catawba Mountain (3201 feet). From about stream mile 11 to the source the valley is quite narrow. The mouth of the creek is at elevation 960 feet, and its maximum elevation is 1800 feet; the total relief is 840 feet. The average total gradient is 56 feet/mile. The lower 10 miles have an average gradient of 35 feet/mile, the upper five miles 9.8 feet/mile. The stream is well-graded; a slight increment in gradient through the gap is indicated in the longitudinal profile (Fig. 2).

Surficial stratigraphy was determined from works by Woodward (11) and Butts (12, 13). Approximately the lower 3.7 miles cross calcareous and shale strata, each occurring in the Rome Formation (stream miles 0.0–0.5, 2.0–2.5), Elbrook Dolomite (0.5–2.0, 2.5–3.0) and Athens Shale (3.0–3.7). The re-

Physical and chemical parameters of Mason Creek (Dates are for width, depth and discharge. Chemical and temperature determinations made 23 December 1971. Dash denotes compound, ion or element not detected).

		Station (S	tream mile)		
	1(0.6)	3(4.5)	5(8.1)	7(12.5)	
Date, November 1971	15	1	8	8	
Width feet \bar{x}	31	30	15	11	
Depth inches \bar{x}	11	8	8	8	
Discharge cfs	17.9	23.9	12.3	6.2	
Elevation feet	980	1100	1240	1680	
Temperature air °C	3.5	3.5	4.0	5.0	
Temperature water °C	3.0	4.0	5.5	5.5	
Dissolved O ₂ ppm	14.0	13.0	12.0	11.4	
Dissolved CO ₂ ppm	≤ 5	≤ 5	≤ 5	≤ 5	
рH	8.1	7.5	7.3	7.2	
Alkalinity, Ph-ln gr/gal CaCO₃				_	
Alkalinity, MO gr/gal CaCO₃	3.6	1.2	0.8	0.4	
Ca hardness gr/gal CaCO ₃	3	1	1	1	
Mg hardness gr/gal CaCO₃	2	1	1	1	
Acidity, free gr/gal CaCO ₃		_		_	
Acidity, total gr/gal CaCO ₃	0.4	0.4	0.4	0.4	
NO ₃ and/or NO ₂ —nitrogen ppm	0.22	0.11	0.11	0.02	
NO ₂ —nitrogen ppm	_				
NH ₄ —nitrogen ppm			_		
PO ₄ ortho ppm	0.20	0.20	0.18	0.14	
Cu ppm	_				

mainder of the creek is bedded on shales and sandstones of the Romney Shale (3.7–3.8, 11.0–15.0), Chemung Formation (4.0–6.0) and Braillier Shale (3.8–4.0, 6.0–11.0). The main surrounding ridges of the middle and upper creeks are capped largely with sandstones and shales containing few calcareous rocks, comprising the Chemung and Price formations, Clinch Sandstone, Martinsburg and Braillier shales, and Heidelberg Limestone.

Mason Creek is a warm water stream in its middle and lower sections. During early May 1969 at an afternoon air temperature of 30°C the stream at mile 4.5 was 22°C. At the same locality on the afternoon of 6 June 1971 with 32°C air temperature the creek was 21°C. The next afternoon with the same air temperature the water rose to 25°C. Chemical characteristics are listed in Table II. Alkalinity from carbonates, hardness and pH significantly increased in the lower creek, where it crosses calcareous strata. It is notable that orthophosphate values are higher than those of nitrate at the upper three stations sampled.

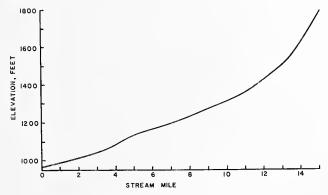


Fig. 2—Gradient profile of Mason Creek.

The creek is of the hard bottom type, with appreciable amounts of sand, silt and mud accumulating only in the quieter portions of relatively large or deep pools. Riffles are typically floored with various proportions of gravel and rubble which are not firmly anchored. Boulders are common along the stream; boulder and bedrock bottoms are frequent in the section through the gap and downstream for about two miles. No trenchant longitudinal differences in bottom type that would markedly affect fish distribution, as determined in this study, were noted. Higher aquatic vegetation is sparse. Beds of water willow (Justicia) are occasional in the lower creek. The water is clear except when affected by rain, after which it clears fairly quickly.

Along the banks of much of the lower creek, in the eastern sector of the City of Salem, are several industries, a large amusement park, horse stables and permanent homes. The middle and upper basin is rural, with numerous crop farms, stock pastures and permanent and summer dwellings. The mountain slopes are almost entirely forested. Slight evidence of increased eutrophication in the lower creek and an apparently industrial effluent of unknown nature entering at mile 2.2 (just above the Route 11–460 bridge) were seen. Portions of the headwaters are being relocated or harmfully altered by road widening. The creek receives some sport-fishing pressure, but it is not a popular fishing stream. Non-game fishes were common or abundant at all stations except, for unknown reasons, station 6.

Four spillway dams that have been temporary barriers to fishes are present. They are located at miles 3.1, 3.2, 5.9 and 6.8 and range from about four to six feet in height. The uppermost dam creates a pond of about four acres surface area, the others about one acre. The gates of the dams frequently

have been removed for purposes of log jam and silt removal, permitting passage by fishes.

Annotated List of Species

Salmonidae, Trout Family

Rainbow trout, Salmo gairdneri Richardson, and brown trout, S. trutta Linnaeus, neither native to the Roanoke drainage, are stocked in Roanoke River at about two miles and farther upstream from the mouth of Mason Creek. Their survival is poor in the Salem area. They are rarely caught by anglers in the creek, and neither species was collected or observed in our survey.

Esocidae, Pike Family

Esox niger Lesueur, Chain Pickerel. Collection 2a, c, 3b, 5a, 6. Juveniles and adults as large as 14 inches total length seined; one of about 16 inches total length seen at station 2. Inhabited shallows and deeper portions of pools.

Cyprinidae, Minnow Family

Campostoma anomalum michauxi Fowler, Stoneroller. All collections except 5a. Found in all habitats at all stations. Adults not taken at stations 4, 5 and 7 and rare at station 6. Young and juveniles uncommon at upper four stations.

Clinostonus f. funduloides Girard, Rosyside Dace. Collections 4a, 5a, b, 6, 7a. Headwater pool inhabitant; young to adults taken in varying abundance as for downstream as station 4.

as far downstream as station 4.

Cyprinus carpio Linnaeus, Carp. Introduced species not seen in our survey; individuals reaching about two feet in length reported present in some of the impoundments.

Exoglossum maxillingua (Lesueur), Cutlips Minnow. Collections 1c, 2a, c, 3a. Uncommon or rare inhabitant of slower waters of lower creek. Only young and juveniles collected; population probably

small as not observed constructing nests.

Nocomis I. leptocephalus (Girard), Bluehead Chub. All collections except 7a, b. Typically an inhabitant of moderate to fairly small-size streams, not extending into small brooks (14; this study). Young to adults common to abundant at lower four stations; uncommon and represented only by young at stations 5 and 6; not found at station 7. Frequently found in all habitats.

Nest-building by bluehead chubs was commonly observed in various sections within stream miles 2.0–5.0 in 1969 and 1971. Nests were not found at a few localities between miles 6.0 and 7.0, but reproduction probably occurs there and somewhat farther upstream based on the presence of young. The lowermost section of the creek, where spawning probably occurs, was not visited during the 1969 and 1971 spawning periods, nor was the creek visited in May and June of 1970. In 1969, the spring was "early" and accompanied by little rain. In the area of stream miles 4.0–4.5, no nests were found on 28 April; however, by 4 May the peak of spawning had been concluded. Water temperatures reached into the 21–23°C range during this interim. In the same creek

section during 1971, a somewhat "late" spring occurred with much rain during May and June. The peak of nest-building took place about 6–7 June; early afternoon water temperatures were 21–25°C. At least one of the following cyprinid species was associated with each active nest observed: Campostoma anomalum, Notropis ardens, N. albeolus, N. cerasinus and Phoxinus oreas; all five occurred at the same time over less than 10% of the nests in both years. The latter four species were apparently spawning; the purpose(s) of the association by Campostoma was not clear.

The Roanoke River in the Salem-Roanoke area is the only known lengthy section of a moderate-size stream where N. leptocephalus clearly is numerically dominant over its relative N. raneyi Lachner and Jenkins, the bull chub. N. raneyi replaces or is generally more abundant than N. leptocephalus in other moderate-size and larger streams of the Roanoke drainage where the species are sympatric (14). Numbers of specimens of *Nocomis* reported from the lowermost station (7) of Cairns, et al. (5) suggest that their relative abundance in the Roanoke River is not exceptional. The following are corrections of records by these authors: station 7, N. leptocephalus 15 (specimens were taken), N. raneyi 5; station 6, N. leptocephalus 22, N. raneyi 2; station 5, N. leptocephalus 3, N. raneyi 3. (The total numbers of *Nocomis* previously reported from these three localities apparently are in error, based on data in the accession catalog at Virginia Polyteehnic Institute and State University; none of the Nocomis from stations 1, 3 and 4 were located.) Both species were collected from the Roanoke by Jordan (3), as indicated by Lachner and Jenkins (14).

Notropis albeolus Jordan, White Shiner. Collections 1a, b, c, 2a, b, c, 3a, b, c, 4a, b. Common in quiet waters of lower four stations, where young to adults captured. Most of the relatively few specimens from runs were adults.

from runs were adults.

Notropis a. analostanus (Girard), Satinfin Shiner. Collection 1a. Adults uncommon in pools near mouth.

Notropis ardens (Cope), Rosefin Shiner. Collections 1a, b, c, 2a, b, c, 3a, b, c, 4a, b, 5a, b. Abundant from mouth to station 4; rare at station 5. Young to adults at the five stations. Distinct preference for pools.

Notropis cerasinus (Cope), Crescent Shiner. All collections except 7a, b. Ubiquitous; penetrates slightly farther upstream than close relative in subgenus Luxilus Rafinesque, N. albeolus; more abundant than latter where collected together. Young to adults at all stations where species found. Most common in pools; most individuals inhabiting runs and riffles were adults.

Notropis hudsonius (Clinton), Spottail Shiner. Collections 1a, c. Juveniles and adults found only in larger pools throughout station 1, where common but not as numerous as the two species of Luxilus.

Notropis procne (Cope), Swallowtail Shiner. Collections 1a, b, 2a, b, 3a, 4a, b, 5a, b. Pool species of the lower and middle creek, where generally

common. Young to adults in most collections including those from station 5. Raney (15) recognized the subspecies N. procne longiceps (Cope) from the Roanoke drainage, but we defer subspecific identification because of dubious distinction (16, 17).

Notropis v. volucellus (Cope), Mimic Shiner. Collections 1a, 4a. Juveniles and adults of this riverine species taken only over soft bottoms in pools near the mouth and, oddly, one young collected at station

Phoxinus oreas (Cope), Mountain Redbelly Dace. Collections 1a, b, 2c, 3a, 5a, b, 6, 7a, b. Although found from mouth to headwaters, it clearly increased in abundance upstream (discounting station 6, at which fishes were quite scarce). Only adults taken at station 1, whereas young to adults occurred at others. Typically a pool dweller, but not uncommon in slower runs.

Pimephales notatus Rafinesque, Bluntnose Minnow. Collections 1a, b, c, 2c, 3a, 4a, b. Common species of lower creek; apparently disappears from fauna between stations 4 and 5. Young to adults taken in lower creek and a prenuptial male captured with collection 3b. Much more numerous in pools than runs. P. notatus was collected from the Roanoke River in 1952 by Raney and Ross, although not so indicated by Cairns, et al. (5). This species probably is not native to the Roanoke drainage (14, 16).

Rhinichthys a. atratulus (Hermann), Blacknose Dace. Collections 7a, b. Brook species found only at the uppermost station. Young to adults common in

pools, uncommon in runs.

Semotilus atromaculatus (Mitchell), Creek Chub. Collections 7a, b. A species of small creeks in the upper Roanoke drainage. Young to large juveniles commonly taken in pools.

Catostomidae, Sucker Family

Catostomus c. commersoni (Lacépède), White Sucker. Collections 1a, b, c, 2c, 3a, b, 4a, 5a, b, 6. Widely distributed in the creek; although not captured at station 7, adults observed about 400 yards downstream from it on 6 June. Young or juveniles from pools of stations 1-6. Large population of adults discovered at station 1 by electrofishing deeper, well-sheltered areas; many adults observed at station 2. Adults not taken but probably present at or near stations 3-6. White suckers numerically composed more than 90% of the suckers collected at stations 1 and 2.

Hypentelium nigricans (Lesueur), Northern Hog Sucker. Collections 1a, c, 2c, 3a, 6. Rare when found and, although occurred upstream to station 6, it was absent from several collections. Only one young and one adult taken at station 1, three juveniles to adults at station 2 and 3, and one adult at station 6. Juveniles and adults occupied riffles, runs and pools; the young from a pool.

Moxostoma ariommum Robins and Raney, Bigeye Jumprock. Collections 1a, c. Found only at station 1; three young and one adult taken. Captured in riffles and pools in Mason Creek, but adults may more frequently inhabit deep runs and the young, pools (18).

It has been suggested for inclusion on the "List of rare, endangered and depleted species," with rare status.

Moxostoma cervinum (Cope), Black Jumprock. Collections 1a, 3c. One adult taken at station 1, from a run. Several adults captured with collection 3a, from a riffle seined in each of our collections from the station. Young found in pools of Roanoke River.

Moxostoma erythrurum (Rafinesque), Golden Redhorse. Collections 1a, c, 2c. One young and one juvenile taken from a pool at station 1 and several juveniles from long pool just above the Route 11-460 bridge at station 2. One of the three species of the subgenus Moxostoma Rafinesque known from Roanoke drainage above the City of Roanoke.

Two species of the subgenus Moxostoma, M. pappillosum (Cope) and M. collapsum (Cope), were reported from the Roanoke River by Cairns, et al. (5). The two reported specimens of M. pappillosum were not located; it is widely distributed in the upper Roanoke River. M. collapsum was placed in the synonymy of M. anisurum (Rafinesque) by Jenkins (18). Of specimens reported as M. collapsum by Cairns, et al. (5), the following were identified by Jenkins as M. anisurum: the one from station 6, the two from station 7, and two of the four from station 1; the others from station 1 are M. erythrurum.

Moxostoma rhothoecum (Thoburn), Torrent Sucker. Collections 1a, 2c. Taken once, uncommonly or rarely, in riffles at lower two stations. Literature records of Moxostoma hamiltoni (Raney and Lachner) for the upper Roanoke drainage proper are based on M. rhothoecum (18).

Ictaluridae, Catfish Family

Ictalurus nebulosus (Lesueur), Brown Bullhead. Collection 1c. One juvenile shocked from a log jam in pool beneath bridge over upper section of station 1. Probably occurs in smaller impoundments farther upstream.

Noturus insignis (Richardson), Margined Madtom. Collections 1a, 3a, 4b. Total of five juveniles to adults taken from a pool, run and riffle of station 1, and one adult found in riffle at stations 3 and 4.

Centrarchidae, Sunfish Family

Ambloplites r. rupestris (Rafinesque), Rock Bass. Collections 1a, b, 4. Five subadults to adults collected at or just above mouth of creek; one juvenile from station 4. All from pools. This widespread form is not native to the Roanoke drainage. Cairns, et al. (5) reported their upper Roanoke specimens as intergrades, A. rupestris: cavifrons (Cope) x rupestris. Jenkins located only the specimens from stations 1 and 5, and identified them as A. r. rupestris. Systematic problems with Ambloplites (1) are being studied by R. C. Cashner, Tulane University.

Leponiis auritus (Linnaeus), Redbreast Sunfish. Collections 1a, b, c, 2c, 3a, 4b, 5a. The most abundant centrarchid of the creek. Young to adults commonly collected or observed in pools from mouth to station 4; one young and one adult taken at station 5.

Lepomis gibbosus (Linnaeus), Pumpkinseed. Col-

lections 1a, b, c, 2c, 5a, 6a. Penetrated farther upstream than the other centrarchids, although less abundant than *L. auritus* and not taken at stations 3 and 4. Young to adults occurred in pools.

Lepomis macrochirus Rafinesque, Bluegill. Collections 1a, b, c, 2c, 4a. Young to adults of this pool inhabitant uncommon the few times found. Regarded

as introduced into Roanoke drainage (1).

Micropterus d. dolomieui Lacépède, Smallmouth Bass. Collections 1a, 2b, c, 3a. Uncommon in pools of lower creek. Most specimens were young; largest observed approximately 10 inches total length. Not native to Roanoke drainage.

Micropterus s. salmoides (Lacépède), Largemouth Bass. Collection 1a, 2c. One young from a pool at

stations 1 and 2.

Pomoxis annularis Rafinesque, White Crappie. A total of five specimens of this introduced species caught by angling in lowermost impoundment and pool approximately one half-mile downstream from this impoundment since 1969 by B. E. Ingram. No crappies taken in our survey.

Pomoxis nigromaculatus (Lesueur), Black Crappie. Introduced species. Two were caught from lowermost impoundment during 1970 by B. E. Ingram.

Percidae, Perch Family

Etheostoma flabellare Rafinesque, Fantail Darter. All collections. Young to adults usually common from mouth to headwaters. Juveniles and adults typically occupied riffles and runs; most young found in pools. Subspecific identification of the Mason Creek population is pending a comprehensive systematic study.

Etheostoma n. nigrum Rafinesque, Johnny Darter. Collections 1a, b, 2a, c, 3a, b, c, 4a, b, 5a, b. Commonly represented in quiet waters of lower and

middle creek by young to adults.

Etheostoma podostemone Jordan and Jenkins, Riverweed Darter. Collections 1a, b, c, 2c. This species and the preceding one are members of the subgenus Boleosoma DeKay with largely complementary habitat distributions. Juveniles and adults of riverweed darter typically occupied swift waters, but were found only at the lower two stations.

Percina crassa roanoka (Jordan and Jenkins), Piedmont Darter. Collections 1a, 2c, 3a, b, c. Adults and larger juveniles of this common to uncommon lower creek form typically inhabit swifter waters, whereas the young tend to occur more frequently in

quieter waters.

Percina rex (Jordan and Evermann), Roanoke Logperch. Collections 1a, 2a, b. Rare in the lower creek; a young and a juvenile seined at station 1, and five adults from station 2. Juveniles and adults occur in all macrohabitats, whereas the young apparently restrict themselves to quiet waters. This species has been proposed for placement on the "List of rare, endangered and depleted species," with rare status.

Discussion

The known native fish fauna of Mason Creek comprises 31 species and six families, a fairly diverse fauna for a small stream. The presence of four addi-

tional species collected, Pimephales notatus, Ambloplites r. rupestris, Lepomis macrochirus and Micropterus d. dolomieui, is thought to have resulted from introductions. Five other introduced species, not seen in our survey, are Salmo gairdneri, S. trutta, Cyprinus carpio, Pomoxis annularis and P. nigromaculatus. The fauna is basically that typical of the upper Roanoke drainage. No evidence of recent occurrence in Mason Creek of the following five native species of the upper Roanoke was found; they may be permanent residents of the creek well above its mouth, but now rare or very restricted in range in the creek, or they have been extirpated: the American eel, Anguilla rostrata (Lesueur); brook trout, Salvelinus fontinalis (Mitchell); Roanoke hog sucker, Hypentelium roanokense Raney and Lachner; mottled sculpin, Cottus b. bairdi Girard; Roanoke bass, Ambloplites cavifrons Cope. The eel was said by Jordan (3) to be common during 1888 in the upper Roanoke, assumedly inclusive of Mason Creek. The last eel report from above Roanoke was of an individual observed about 1940 (4). The 52 feet high Niagara power dam, constructed in 1906 across Roanoke River about four miles below Roanoke, probably impeded upstream passage of this catadromus species; more recently constructed, larger dams below Niagara Dam enforce this barrier. H. roanokense is widely distributed in the upper and middle Roanoke drainage, where it is endemic (19). Although it is absent or rare in the Roanoke River from the Salem area downstream, it is typically found in small streams with its close relative, H. nigricans. Our failure to find it was as surprising as the rarity of H. nigricans in the creek. The brook trout and mottled sculpin are cool or cold water species restricted in the Roanoke to its upper portion. Their absence from Mason Creek probably relates to temperature regimes and intermittency in the headwaters. A. cavifrons probably occurred in the creek but was replaced by A. r. rupestris.

All Mason Creek species, except that of Esox, and the small-stream Clinostomus, Phoxinus, Rhinichthys and Semotilus, are typical of the upper main channel of the Roanoke River. The following eight species, most of which are riverine forms and all of which are known at least as far up Roanoke River as Salem, may migrate into lower Mason Creek to spawn, or occur in the creek as waifs: bowfin, Amia calva Linnaeus; bull chub, Nocomis raneyi; golden shiner, Notemigonus crysoleucas (Mitchell); Quillback, Carpiodes cyprinus (Lesueur); silver redhorse, Moxostoma anisurum (Rafinesque); V-lip redhorse, M. pappillosum (Cope); orangefin madtom, Noturus gilberti Jordan and Evermann; shield darter, Percina peltata (Stauffer). Six of these species, excepting Amia and the quillback, are widely distributed in the upper Roanoke. An adult Amia was caught in 1962 by an angler from a small impoundment of the Roanoke in western Salem; a photograph of the specimen appeared in the Roanoke Times (27 June 1962), and scales from it were identified by Jenkins. R. E. and D. J. Jenkins observed a bowfin of about 20 inches length in the South Fork Roanoke River just above Alleghany Springs. It was seen in clear water from a distance of five feet, on 27 May 1970 in an area where many cyprinids were spawning. The bowfin may have originally been introduced into the upper Roanoke. If so, its presence in the soft-bottomed impoundment would not be unexpected, but its occurrence in the South Fork, a moderate gradient, largely hard bottom stream, is most surprising. The quillback was reported from the Roanoke River by Trautman (20). The specimen on which this record is based was taken in eastern Salem, and was deposited at the Museum of Zoology, University of Michigan. An angler informed Jenkins of snagging a quillback in the Roanoke of eastern Salem.

The species reported from Mason Creek and those mentioned above constitute the known fauna of the upper Roanoke drainage from Salem upstream. They total 53 of the 105 members of the freshwater Roanoke fauna, or 44 of 83 of the total native forms (1). One specimen of Hybognathus nuchalis regius Girard was reported (5) to have been taken in the upper Roanoke by Raney and Ross in 1952, and a specimen was also recorded from station 1 of Cairns, et al. (5). These records are not accepted. Jenkins was unable to locate either specimen at Cornell University or Virginia Polytechnic Institute and State University. Hybognathus is unknown in the Roanoke drainage above its lower Piedmont section. Only one record is from the Piedmont (21); many are from the Coastal Plain section. Pflieger (22:365, Map 80) recognized regius as meriting elevation to specific status. Previously, Bailey (23) provisionally continued to treat regius as a subspecies of nuchalis, alluding to the differences given by Hubbs and Lagler (24) as being inadequately quantified or broadly overlapping. Al-Rawi and Cross (25) found a difference between the forms in the shape of the basioccipital process. Pflieger's consideration presently seems to be the more favorable one, partly since he has shown that three Mississippi basin nominal species of Hybognathus, regarded as conspecific at earlier times, remain distinctive where sympatric. In addition, the shape of the basioccipital process is of considerable taxonomic importance in Hybognathus (22, 25–27).

Faunal diversity in Mason Creek increased regularly from the headwaters to its mouth, with six species taken at station 7 to 31 at station 1 (Table I, which excludes records by anglers). The progressive increase in diversity generally relates to addition of species, rather than replacement of upstream forms. Only four species failed to persist, in the downstream direction, to the creek mouth. Two of these, Rhinichthys atratulus and Semotilus atromaculatus, occurred only at the uppermost station, whereas Clinostomus funduloides extended down to station 4. Esox niger was not taken at Station 1, but it occurs, rarely, in the Salem area of Roanoke River. The trend in diversity is typical for fishes and other organisms in small to moderate-size unpolluted streams (among recent works: 28-30).

A pattern of longitudinal zonation is obvious for most species. Most of those found only at station 1 or 1 and 2 are more common, in the upper Roanoke drainage, in streams larger than Mason Creek. Of the 29 species found at two or more stations, a hiatus was indicated to occur in the range of only nine. For most of the nine, the gap probably relates to inadequate collecting, e.g. for centrachids in deep pools. Only two species, *Campostoma anomalum* and *Etheostoma flabellare* were found at all stations. *Catostomus commersoni* approached being this widely distributed; *Phoxinus oreas* probably occurs at station 4 in addition to being found at all other stations.

The largest number of species (32) occurred in pools, and the smallest number (12) in riffles; the somewhat intermediate habitat, runs, yielded 19 species (Table I). Considering relative abundance of both juveniles and adults in the three habitats, only six of the 35 species listed apparently prefer riffles; they are benthic fishes of the sucker tribe Moxostomatini-Moxostoma ariommum, M. cervinum and M. rhothoecum, and darters—Etheostoma flabellare, E. podostemone and Percina crassa roanoka. The paucity of riffle forms probably relates in part to greater rigors presented by current velocity in this habitat. No species seemed to prefer runs, or at least none clearly were numerically more abundant in such habitat than in riffles or pools. A possible explanation is that one of the main features by which this habitat was recognized—less turbulence—is effected by fewer rocks and thus less cover. Campostoma anomalum and Nocomis leptocephalus were about equally abundant in all habitats. A habitat preference was not detected for Hypentelium nigricans, Noturus insignis and Percina rex, as they were not collected frequently enough in the creek. They occurred in a variety of habitats in other streams, and N. insignis was closely associated with shelter. Pools were preferred by the other 24 species, including most cyprinids and all centrarchids (for rare species, this conclusion is based on collections from other streams). The relation between stream depth and diversity was discussed by Sheldon (30) and by Hanson and Campbell (31). Young specimens of species whose adults prefer riffles typically occurred in the quieter margins of riffles and in pool shallows. Adults of some of the pool species, notably Notropis albeolus and N. cerasinus, were more frequently found in moderate to rapid currents than were smaller individuals. During reproduction the habitat of the cyprinids associated with Nocomis nests and of pooldwelling catostomids often or typically shifts to swifter waters.

Fishes in general were common and about equally abundant at all stations except 6, where they were quite scarce. No distinct differences were noted in habitats between this and other stations except, as expected, in depth and width. Although the predatory *Esox* was common, and probably effected some control of forage species populations, it was also common at other stations. The lower basin is urbanized and industrialized, but the fauna does not appear to have changed significantly in composition and abundance from that noted by Jordan (3).

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Especially for Science and Mathematics Teachers

Ideas Questions Opinions

A Simple Nutrition Experiment for Secondary Grades

Abstract—A simple animal nutrition experiment demonstrated to children in the secondary grades the nutritive value of various foodstuffs. After this experience they

helped plan family menus.

I want to describe a simple experiment that will demonstrate to children in the secondary grades the nutritive value of various foodstuffs. Briefly, the experiment is to maintain hamsters on specified diets, and weigh the animals periodically to observe weight changes. The experiment can be performed with a minimum of equipment and materials, and can be maintained in school rooms or in the home with little trouble. Good results can be obtained in 2–3 weeks.

This experiment was first designed as a demonstration for my children, ages 7, 10, 12, and 13. These children wanted to eat only cold (dry) cereal for breakfast. (I suspect this is the case with many American children.) I found it difficult to get my children to eat other foods at breakfast. While the breakfast cereals have their value, I believe children should have a well balanced, varied diet. I saw an opportunity to show them the value of good nutrition when our pet hamsters littered. When the little hamsters were of weaning age, the children and I started the following experiment to demonstrate the nutritive value of various foods.

Experimental Procedure

Weanling hamsters (23 days old), all of the same sex, were weighed and put into cages. Three animals were put in each of three cages, and were kept on a diet of commercial rodent chow for the first three days after weaning. The animals were again weighed at the end of this time. Then the diets in two of the cages were changed, one to a popular dry breakfast cereal, and the other to a dry dog food. The third cage of hamsters was kept on rodent chow as a control diet. Food and water were supplied to all animals ad libitum. The hamsters were then weighed about every other day for a period of two weeks. While experiments of this kind usually involve white rats, I believe for this work the hamster is to be preferred esthetically. Children and teachers will enjoy working with hamsters rather than rats.

The weanling hamsters should be obtained from a biological supply house, as pet stores usually do not stock weanling animals. The weanling hamster will cost about one dollar apiece. Cages, with an exercise wheel, a water bottle, and a feeder can be purchased at pet stores for about five dollars apiece.

Litter for the cages and rodent chow usually can be purchased at pet stores. The litter in the cages should be changed at least once a week. The children can also handle this job. Manuals on the care of hamsters can be purchased at pet stores. For additional information on the care of hamster and other rodents one can write to Ralston-Purina Co., St. Louis, Missouri.

To get the weight of the hamsters, a small coffee can (with lid) is weighed. Then all hamsters from one cage are put in the can, and the can plus hamsters is weighed. The difference in the weight of the can plus hamsters and the weight of the can alone, is the weight of the three hamsters. The average weight can be calculated by dividing the total weight by the number of animals weighed. The periodic weighings are recorded as in Table I. A graph of average weight versus time is made for each diet. The children may better understand the experiment if the results are graphed. The children can do the weighing and the graphing.

TABLE I

Average weights of hamsters versus days on various diets.

		Average	Weight of A	nimals	
Day of Experiment		Cage I Rodent Chow	Cage 2 Dog Food	Cage 3 Dry Cereal	
Day	1	45.7 g	37.0 g	47.7 g	
	4	48.0	42.5	47.5	
	5	49.0	44.0	46.5	
	6	57.5	48.0	45.5	
	8	57.5	50.0	43.0	
	10	59.0	57.0	42.0	
	11	60.5	51.5	42.5	
	13	59.0	59.5	41.5	
	15	60.3	62.4	42.5	
-		Dry Cereal	Oatmeal	Rodent Chow	
	16	60.8	64.7	43.0	
	19	64.4	70.8	53.6	
	21	63.0	69.5	57.8	
	23	63.0	74.4	63.6	
	25	67.6	71.5	70.6	
	27	66.8	72.6	78.6	
	29 60.2		77.6	85.5	

Cage 1: The diet was rodent chow from Day 1 to Day 15, then it was changed to dry cereal.

Cage 2: The diet was dog food (dry pellets) from Day 1 to Day 15, then it was changed to dry oatmeal.

Cage 3: The diet was dry cereal from Day 1 to Day 15, then it was changed to rodent chow.

Results and Discussion

At the end of 14 days the hamsters on the diet of dry cereal had lost weight. These animals showed symptoms of poor nutrition in having poor coats and being in an emaciated condition. The animals in the other cages, on diets of rodent chow and dog food, had gained weight normally and seemed to be in good health. The children could see the differences in the animals, and could readily understand that this was due to the different diets.

The diets in each cage were now changed. Those animals that had been on dry cereal were put on rodent chow; those that had been on dog food were put on dry oatmeal; those that had been on rodent chow were put on dry cereal. Again the animals were supplied with food and water *ad libitum*, and kept on these new diets for 14 additional days. The animals were weighed every two days and these

weighings were graphed as before.

The animals changed from a diet of dry cereal to rodent chow began to gain weight immediately and at the end of 14 days had weights expected of normal hamsters of this same age. In all respects they appeared to be quite healthy. In the meantime the weights of those animals changed from rodent chow to dry cereal began to level off after 4 days on the new diet. At the end of the 14 day period these animals began to lose weight. The hamsters changed from dog food to oatmeal continued to gain weight, but at a reduced rate. Again, the children could readily see and appreciate the meaning of these changes.

These experiments show that dry breakfast cereals alone were inadequate to maintain the normal growth rate and general health of the hamsters. The dry oatmeal was shown to occupy a position between the dry cereal and the rodent chow. The rodent and dog chows are mixed foods and are nutritionally complete. Cereals are single foods of limited nutritional

value. As a result of these experiments the children did see the value of different foods in the hamsters diet, and they could understand that humans and hamsters (both being animals) have similar nutritional requirements.

tional requirements.

The children were instructed to read the labels on the food packages to determine the nutrient content of the foodstuff used in the experiment. As part of the instruction, the children should be told that food is made up of many components. A good diet needs not only proteins and vitamins, but also fats, carbohydrates and minerals in balanced proportions. The children should understand that it is not only the quantity, but also the quality of the food that is needed for good nutrition. In reading food package labels they saw that many human foods and animal foods have similar composition.

While the children did not like oatmeal any better (nor dry cereal any less) they did realize the need to vary their diet. The children were anxious to try other foods, such as various vegetables, in the hamsters diet (but not necessarily in their own diet). They understood that some foods were better than others, and that they should learn the difference. As a result of this study, the children helped me prepare

the weekly menus for our family.

Acknowledgement

Michael Hardcastle (age 10) did most of the caring for and weighing of the animals. He recorded the weights, and any other pertinent observations, in a bound notebook. Francie, Julie, and Andy Hardcastle (ages 13, 12, and 7 respectively) gave valuable assistance on this project.

J. E. HARDCASTLE Assistant Professor of Biochemistry Chemistry Department Texas Woman's University Denton, Texas 76204

News and Notes

J. STANTON PIERCE

Dr. J. Stanton Pierce, Professor Emeritus of Chemistry at the University of Richmond, died on July 22, 1972. Dr. Pierce retired in 1971 after serving on the University of Richmond Faculty for thirty-

four years.

Dr. Pierce received the B.S. degree from Georgetown College in 1920, the M.S. degree in 1921 and the Ph.D. degree in 1924 from the University of Illinois. In 1924 Dr. Pierce returned to Georgetown College as Professor of Chemistry, where he remained until 1937 at which time he came to the University of Richmond. In addition to serving as Professor of Chemistry, Dr. Pierce was Chairman of

the Department from 1947 to 1953.

Dr. Pierce was active in the American Chemical Society throughout the period of more than fifty years during which he was a member. Before coming to Virginia he served as Chairman of the Lexington, Kentucky section of A.C.S. While at the University of Richmond Dr. Pierce served on numerous committees of the Virginia section including the Executive Committee, and held a number of offices. In 1963 he received the Distinguished Service Award of the Virginia Section.

Dr. Pierce served as Treasurer of the Virginia Academy of Science and also as Secretary and Chair-

man of its Chemistry section.

Dr. Pierce was an able and devoted teacher who guided many students into research and graduate study in chemistry. He was very active in research and published numerous articles in chemical journals. He obtained a number of patents covering organic compounds in various fields.

SCIENCE MUSEUM NEWS

Dr. Paul H. Knappenberger has been named associate director in charge of the Science Museum of Virginia's Capital Division (Richmond Region) physical sciences facility. The appointment, effective January 1, 1973, was announced by Dr. Roscoe D. Hughes, chairman of the Museum's Board of Trustees.

Knappenberger, who received M.A. and Ph.D. degrees from the University of Virginia in astronomy, will also serve, for the time being, as acting director of the Capital Division, and acting director of the total Museum system. He also will be associated with Virginia Commonwealth University as an assistant professor of physics on a part-time basis.

Currently, Knappenberger is serving as assistant director of the Fernbank Science Center in Atlanta, and holds teaching postions at both Emory and Georgia State Universities. Since joining the Fernbank staff in 1968, he has shown a special interest in coordinating physical science programs for elemen-

tary, high school, undergraduate, and graduate students.

A Pennsylvania native, he has participated in national TV coverage of the Apollo moon missions, and among other duties at Fernbank has been responsible for the design and construction of scientific equipment; and computer programming, with emphasis on trajectory and orbital computations. During the total eclipse of the sun in March 1970, he led a team of scientists, teachers, and students into the area of totality where experiments in astronomy, meteorology, and biology were conducted.

Knappenberger has received a NASA graduate fellowship and research grant and is a member of Pi Mu Epsilon honorary fraternity, the American Astronomical Society, American Institute of Physics,

and the Georgia Academy of Science.

Preparation of a Master Plan, which will include details as to type and location of structures, short and long term expansion possibilities, operating costs, and the relationship of the Museum to other community cultural and educational activities, has begun for the Capital Division (Richmond Region).

This document is of vital importance since it will enable the Board of Trustees to make definite decisions as to phasing and establishment of Museum units and facilities. It will also be valuable in seeking funds from friends of the Museum, foundations, the federal government, and other non-state sources.

RTKL, Inc., a nationally known planning/urban design-architectural-engineering firm has been employed for the project, and completion is expected around the end of December. Unfortunately, capital outlay funds were deleted from the Museum's 1972—74 budget requests, but a reappropriation from 1970–72 and the Governor's discretionary fund allocation of \$5000 made sufficient funds available for this project.

However, non-state funds are still needed for master planning in other Museum divisions, as well as for steps required beyond the Master Plan.

The Science Museum of Virginia Foundation, Inc. has been established, and five directors elected by the Board of Trustees of the Science Museum.

Named were: Robert N. Fishburn, editor of the editorial page, Roanoke *Times*, Roanoke; Roscoe D. Hughes, chairman of the Science Museum of Virginia Board, Richmond; George T. Stewart, president, First Colony Life Insurance Company, Lynchburg; T. Dale Stewart, vice chairman of the Science Museum Board, McLean; and Henry L. Valentine, executive vice president of Davenport and Company, Richmond.

Hughes and George T. Stewart were elected for a one year term, Valentine and Fishburn for two years, and T. Dale Stewart for three years. Additional

directors from various areas of the state are expected to be elected to the Foundation in the near future.

Recently chartered by the State Corporation Commission, the Foundation will receive gifts for the development of the Science Museum.

VCU DEAN OF ARTS AND SCIENCES

Dr. Paul D. Minton, new dean of the school of arts and sciences, arrived in Richmond from Dallas, Texas, the day before flood waters raged in the city, but his enthusiasm for taking on the job was not dampened.

Doctor Minton's appointment was effective July 1. He succeeds Dr. J. Edwin Whitesell, who resigned for a full-time teaching position in the department of

English.

Formerly professor and chairman of the department of statistics at Southern Methodist University in Dallas, Doctor Minton said he was attracted to VCU by the challenge of "a new school with a young faculty, not frozen with a traditional curriculum." He particularly anticipates being a part of a university which has as a major thrust the solution of urban problems. His publications demonstrate interdisciplinary applications and interest, with subjects (in addition to statistics) including mathematics, biology, medicine, theology, engineering, and seismology.

Born in Dallas, Doctor Minton received his B.S. and M.S. degrees in mathematics at SMU and his Ph.D. in experimental statistics at North Carolina

State University.

In addition to teaching at SMU and for one year at Virginia Polytechnic Institute and State University, he has worked with Remington Rand Univac, Texas Instruments, Inc., Mobil Co., Atlantic Richfield Co., and Oak Ridge National Laboratory. He has served as consultant in statistics to governmental, industrial, and educational research organizations.

COOPERATIVE CROSSBREEDING RESEARCH

A cooperative research project of crossbreeding for beef production was initiated in 1968 between the Animal Science Department of V.P.I. & S.U. and the Virginia Department of Welfare and Institutions. An outgrowth of an earlier ten year cooperative bull testing program, the present research is conducted at five locations: Beaumont, Bland, Hanover, Southampton, and State Farm. Over 1,000 cows were bred in 1972 by 41 bulls representing eight breeds. The specific objectives are: 1) To evaluate several sire breeds; 2) to compare the productivity of several kinds of crossbred cows with each other and with straightbred cows; and 3) to determine the best combination of breeds and mating schemes for maximizing beef production. This research promises to increase production within these herds by 25% or more, stated Dr. Thomas J. Marlowe, Professor of Animal Science at V.P.I. & S.U. and leader of the project.

POULTRY SCIENCE NEWS

Three poultry science students are benefiting from scholarships awarded to Virginia Tech's department of poultry science by a national chemical company

and two Virginia poultry firms.

Daniel A. Sutton, a sophomore from Timberville, received a scholarship for \$360 from Long Foods, Inc., of New Market. Both James S. Brown, a sophomore from Hamilton, and C. Shields Jones Jr., a sophomore from Esmont, received \$300 scholarships from Rocco Feeds, Inc., of Harrison-

All three scholarships are sponsored jointly by Dow Chemical U.S.A. The funds are part of more than \$67,000 in grants awarded by Dow in a joint program with the poultry industry. The scholarships are provided through contributions from the firms'

profits.

Criteria for the awards included scholastic achievement and financial need, E. L. Wisman, Tech pro-

fessor of poultry science, said.
Dr. Paul B. Siegel, Virginia Tech professor of poultry science, was elected president of the Poultry Science Association at the society's annual meeting at Ohio State University recently. He had served the association as vice-president in 1971 and as a member of the board of directors from 1968 to 1970. He is a past recipient of the organization's research award.

Dr. Siegel received his B.S. degree from the University of Connecticut and his M.S. and Ph.D. degrees from Kansas State University before coming to Virginia Tech in 1957. He is a specialist in the field of poultry genetics and behavior.

Dr. Siegel was president of the Virginia Academy

of Science, 1968-69.

PROFESSOR BEAMS CITED

Dr. Jesse W. Beams, Professor Emeritus of Physics at the University of Virginia and winner of the National Medal of Science in 1968, received a citation from the U. S. Atomic Energy Commission (AEC) in ceremonies November 2 for his work in the development of the gas centrifuge for separating isotopes and in the AEC's use of the process for sepa-

rating uranium isotopes.

Dr. Beams is one of three scientists selected to receive AEC citations. Also named were Dr. Norman G. Anderson, who headed development at Oak Ridge National Laboratory of a centrifuge system for the mass production of a pure influenza vaccine, and Dr. George C. Cotzias, whose Brookhaven National Laboratory team developed the first successful treatment of Parkinson's disease using L-DOPA. The citations were presented in ceremonies at the AEC headquarters at Germantown, Md.

Dr. Beams' citation honors him "for his outstanding contributions to the nation's atomic energy program as a pioneer in the field of gas centrifugation; for his creative and dynamic leadership of the University of Virginia's wartime effort on the gas centrifuge process; for his continued research which culminated in expansion of the Atomic Energy Commission's research and development program; for his expert guidance of the General Advisory Committee, as a member of the Committee of Senior Reviewers

and as a consultant.'

A 1921 graduate of Fairmont College—now Wichita State University—Dr. Beams received his doctorate in physics from the University of Virginia in 1925. He joined the University faculty in 1928, became a full professor in 1930 and was named chairman of the physics department in 1948. He retired in 1969 and was named a Professor Emeritus of Physics and senior research scholar by the University's Board of Visitors.

In 1968 Dr. Beams was awarded the National Medal of Science, the government's highest award for distinguished achievement in science, mathematics and engineering. The medal, presented by President Lyndon B. Johnson, honors him for his work with centrifuges.

He is a member of the National Academy of Sciences and served as president of the American Physical Society in 1958-59. He is a Fellow of the Virginia Academy of Science and was president of the Virginia Academy of Science, 1947–48.

He has received numerous honors, including the Potts Medal of the Franklin Institute, the Lewis Award of the American Philosophical Society and the John Scott Award. He remains a consultant to the AEC.

DISTINGUISHED SERVICE AWARDS

The 1972 Distinguished Scrvice Award of the Virginia Section of the American Chemical Society was presented to Dr. Alfred R. Armstrong, Department of Chemistry of the College of William and Mary, Williamsburg, for outstanding contributions in the advancement of the profession of chemistry.

Mr. William A. Gilbert, chemistry teacher at Waynesboro, High School, Waynesboro, received the Distinguished High School Teaching Scrvice Award for 1972. The awards were presented at an annual

awards program in May.

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